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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXXIII.—*Elaboration of the Fossil Cycads in the Yale Museum;* by LESTER F. WARD. (With Plates II–IV.)

THE visitor to the Peabody Museum of Yale University, if he penetrates to the basement of that building, finds himself literally "in the woods,"—a petrified forest of Mesozoic cycads. A few of the finest specimens may be seen in the exhibition halls on the second floor, and many more will be ultimately placed there, but at present the bulk of the collection is undergoing elaboration below, in close association with the gigantic dinosaur bones that have made the names of Marsh and of Yale so justly celebrated in the history of science. In a very literal sense, cycads are to the vegetable kingdom what dinosaurs are to the animal, each representing the culmination in Mesozoic time of the ruling dynasties in the life of that age. Professor Marsh saw this, and, as the last act of his life, had the sagacity to make the Yale Museum for all time the Mecca for all who shall wish to gain a realizing sense of the fauna and flora of America in a period now forever closed.

It has chanced to be my fortune or misfortune to be situated, as it were, in the storm track of cycadean investigation on this continent, and upon me has devolved the duty of roughly blocking out the general line of study of that wonderful extinct vegetation that has been coming to light in this country in such rich profusion. Science demands a terminology and a nomenclature, and whatever may be said of the superficial character of all systematic work, it is now true and always has been true, nay, it must always be a need, that the systematist precede the structuralist and provide him with a language and a framework for his finer researches. This is all I profess to have attempted, and not

only am I keenly aware of the superficiality and defectiveness of my work, but I have urged on all occasions the importance of the exhaustive study of the wonderful structure of these cycadean trunks that reveals itself to the lens and even to the naked eye. I presented this aspect of the case in the strongest form I could command to Professor Marsh, and pointed out to him the "unlimited possibilities" of such a study of the great Yale collection. I am happy to record his warm appreciation of the fact, which led him actually to inaugurate it some months before his death, by inducing Mr. George R. Wieland to undertake it and by placing at his disposal every possible facility for the prosecution of this work. Professor Marsh's successor, Dr. C. E. Beecher, with the approval of the Trustees of Yale University Museum, has allowed no interruption in these valuable researches, so creditable to the institution, and has placed them on a permanent basis.

I am only to speak here of my own work, much of which I have already recorded and need only allude to,* confining myself to the additional results that have been reached by recent study. As stated in the Nineteenth Annual Report of the U. S. Geological Survey, Part II, pp. 546 and 547, I worked up all the cycad material from the Black Hills in the Yale Museum, in the months of March and June, 1898, and the 22 species described in that report were based on the material in the U. S. National Museum, and on 126 specimens in the Yale Museum, contained in two invoices, the first of 87 specimens and the second of 39. These were illustrated in 97 plates, and that paper constitutes the basis for subsequent and future investigations. It was known at that time that other

* For the benefit of any who may be specially interested, I herewith refer to the following papers of mine relating in whole or in part to fossil cycadean trunks: Fossil Cycadean Trunks of North America, with a Revision of the Genus Cycadeoidea Buckland. Proc. Biol. Soc. Washington, vol. ix, Washington, April 9, 1894, pp. 75–88; The Cretaceous Rim of the Black Hills, Journal of Geology, vol. ii, No. 3, Chicago, April–May, 1894, pp. 250–266; Recent Discoveries of Cycadean Trunks in the Potomac Formation of Maryland, Bull. Torrey Bot. Club, vol. xxi, No. 7, July 20, 1894, pp. 291–299; Some Analogies in the Lower Cretaceous of Europe and America, Sixteenth Annual Report, U. S. Geological Survey, 1894–95, Pt I. Washington, 1896, pp. 463–542, pls. xcvii–cvii; Descriptions of the Species of Cycadeoidea, or Fossil Cycadean Trunks, thus far discovered in the Iron Ore Belt, Potomac Formation, of Maryland, Proc. Biol. Soc. Washington, vol. ix, March 13, 1897, pp 1–17; Descriptions of the Species of Cycadeoidea, or Fossil Cycadean Trunks, thus far determined from the Lower Cretaceous Rim of the Black Hills, Proc. U. S. Nat. Mus., vol. xxi (No. 1141), Washington, 1898, pp. 195–229; The Cretaceous Formation of the Black Hills as indicated by the Fossil Plants, Nineteenth Annual Report, U. S. Geological Survey, 1897–98, Pt. II, Washington, 1899, pp. 521–946, pls. lvii–clxxii; Description of a New Genus and Twenty New Species of Fossil Cycadean Trunks from the Jurassic of Wyoming. Proc. Washington Acad. Sci., vol. i, pp. 253–300, pls. xiv–xxi; Status of the Mesozoic Floras of the United States, First Paper, The Older Mesozoic, Twentieth Annual Report, U. S. Geological Survey, 1898–99, Pt. II, pp. 211–748, pls. xxi–clxxix.

invoices were on their way, but it was impossible to wait for them to arrive and be described before going to press with the Nineteenth Annual Report. They came, however, during the summer, and added 44 specimens to the Yale collection, which I studied in November of that same year, but the results were not then published. In fact, the investigation was purposely left incomplete, because in the meantime, viz., in October of that year, I had been over the entire cycad-bearing area of the Black Hills in company with Mr. H. F. Wells, who had collected all the cycads for Professor Marsh, and had seen on the ground such an immense number of trunks and fragments that I had determined to make every effort to have these added to the collections already made. I had understood from Mr. Wells that Professor Marsh had declined to purchase any more, and I made a strong effort to induce the authorities of the U. S. National Museum to secure them on the extremely reasonable terms for which Mr. Wells offered to do the work. Failing in this, I appealed to Professor Marsh to secure them for Yale, which he did promptly, and before spring they had all arrived.

To give an idea of the extent and wealth of these latest accessions, it is only necessary to say that while, even after the arrival of the third invoice in the summer of 1898, the entire collection numbered only 170 specimens, it now numbers 731 specimens! It is true that many of these are fragments broken from larger trunks, but this was precisely what was needed to complete and perfect the collection. From a scientific point of view, fragments are often more valuable than perfect trunks, since they reveal the internal structure and throw light on the entire nature of the plants. Then again many of these fragments and *disjecta membra* are found to belong to specimens previously received, and add directly to their value. For example, the largest specimen in the collection, which, when the parts were gotten together and weighed, proved to be the largest trunk known in the world, came in different invoices and in four pieces. One branch, No. 145, was in the third invoice, and I had left it unassigned, well knowing that it was incomplete, and hoping that the remainder might ultimately be found. It did in fact arrive, and the parts have been brought into position and mounted in the exhibition hall on the second floor, where it may be seen of all men. Happily it proves to belong to the great branching species which I dedicated to Professor Marsh, and will stand forever as a tribute to his labors in this field—the *Cycadeoidea Marshiana.*

As was naturally to be supposed, and as I fully expected, the greater part of these numerous accessions have been found to belong with more or less certainty to one or other of the 22

species already described, but not only do they complete and supplement the previous collections in the manner above pointed out, but they greatly enrich it by adding many and often much finer specimens than any that existed before. First of all, they have added two species to the Yale collection which were formerly only represented in that of the U. S. National Museum. These are *Cycadeoidea excelsa* and *C. occidentalis*. In the second place, the beautiful *C. pulcherrima*, of which the type is at the National Museum, is now represented at Yale by at least one almost equally fine specimen, while the great *C. Jenneyana*, of which there were only a few broken pieces, now numbers its representatives by scores, some of them very fine trunks. The species which the new accessions have perhaps most richly endowed is the rare *C. Wellsii*, to which three or four huge and superb trunks are now added. Every species known from the Black Hills is now represented in the Yale collection, which was not previously the case, and it is safe to say that that collection constitutes the largest and finest assemblage of fossil cycadean trunks in the world.

Besides the specimens from the Black Hills, the Yale Museum possesses two specimens from the Jurassic cycad bed of the Freezeout Hills of Wyoming, treated by me in the paper above cited in the Proceedings of the Washington Academy of Sciences, and still further illustrated in the Twentieth Annual Report of the U. S. Geological Survey. These are Nos. 127 (*Cycadella Reedii*) and 128 (*C. Beecheriana*), for the completion of which Prof. Wilbur C. Knight of the University of Wyoming, at my suggestion, has given to Yale the complementary fragment, No. 500.54, of his much larger collection from the same bed. There have also been discovered among the forgotten collections in the Yale Museum two fragments of cycads from the Iron Ore Clays of Maryland. When these trunks were refound, Professor Marsh at once remembered that he had secured them in 1867, from Mr. Philip Tyson, the original discoverer of cycads in Maryland. I have examined these specimens, and find them both to belong to the predominant species of that region, *Cycadeoidea marylandica*. They bear the numbers 729 and 730.

There have also now been found in the Yale Museum collections, 7 specimens of cycadean trunks from the original Purbeck forest beds of the Isle of Portland, that overlie the Portland stone. These are in two lots. The first consists of a single specimen, the gift of Dr. Gideon Mantell to Prof. Benjamin Silliman shortly after the attention of paleobotanists had been called to these objects, so long known to quarrymen as "crow's nests." It bears Mantell's label, *Mantellia nidi-*

formis Brongniart, with a reference to the figure in his Wonders of Geology, 1839, p. 365, fig. 70 (or is it to his Medals of Creation, in the later editions of which, but not in the earlier, the same figure occurs?). As the *Mantellianidiformis* of Brongniart is the *Cycadeoidea megalophylla* of Buckland, it is evident that Dr. Mantell supposed the specimen to belong to this species, but it does not agree with his own figure, and seems rather to represent the small-scarred species, *Cycadeoidea microphylla* Buckland. This specimen has been numbered 732 of the Yale collection.

The other lot consists of 6 specimens which were received on Sept. 24, 1898, from Mr. A. N. Leeds, the collector and donor. They have now been given the numbers 733–738. Three of them (Nos. 733–735) belong without doubt to *Cycadeoidea microphylla* Buckland. No. 736 probably belongs to the same species. Nos. 737 and 738 have the large scars of *C. megalophylla*, and undoubtedly represent that species.

I made my fourth visit to the Yale Museum in May, 1900, and commenced work on the new material on the third of that month. My first work was to identify as many of the specimens as possible with previously described species. In many cases this was easy of accomplishment, but in dealing with the immense number of fragments and the imperfect, immature, dwarf, and depauperate specimens that necessarily accompany a complete collection, and which, in spite of the trouble they give, ought always to be collected, doubts constantly arise and cannot be removed. In the list which follows I have expressed such doubts by interrogation marks, and they are taken to indicate the tentative and incomplete character of the work. The future will doubtless greatly change matters in these respects, and the reader is asked to make due allowance for the unsettled state of our knowledge of these objects. A mere list of species with numbers attached is admitted to be unattractive reading, but it nevertheless affords an idea of the relative abundance of the species, and will have value as a guide or catalogue of the collection for any who may wish to study or examine it. An alphabetical arrangement of the species will probably prove more convenient than any attempt at systematic classification. The following are the 29 species thus far known, with the specimens in the Yale collection that have been assigned to each:

Cycadeoidea aspera, No. 104.

Cycadeoidea cicatricula, No. 118.

Cycadeoidea Colei, Nos. 12, 20, 25?, 28?, 48, 52?, 57, 68, 80?, 224?, 240?, 246?, 291, 321, 433, 444, 476?, 539.

Cycadeoidea colossalis, Nos. 2, 7, 10, 13, 17, 37, 40, 55, 133, 238, 333 ?, 351, 354 ?, 438 ? ?

Cycadeoidea dacotensis, Nos. 1, 3, 5, 6, 30, 39 ?, 43, 54, 61 ?, 62, 63, 95 ?, 106 ?, 134, 212, 213, 214, 215, 232, 307 ?, 324, 328, 353 ?, 355, 356, 358, 369, 372, 373 ?, 384 ?, 398, 425 ?, 435, 503 ?, 504 ?, 505 ?, 508 ?, 509, 510, 511 ?, 512, 513, 516 ?, 518, 523 ? ?, 525, 526, 528, 530, 538, 542, 543, 546, 547, 548, 549, 550, 716 ?, 719 ?, 720 ?

Cycadeoidea excelsa, Nos. 236, 239, 248, 370 ?, 453, 455, 461 ?, 479, 481, 498.

Cycadeoidea formosa, Nos. 89, 611, 615 ?, 639 ?, 641 ?

Cycadeoidea furcata, Nos. 18, 60, 718.

Cycadeoidea heliochorea, Nos. 722, 723, 724, 725, 726.

Cycadeoidea ingens, Nos. 92, 94, 99, 100, 103, 110, 117, 122, 123, 208, 554 ?, 557 ?, 560 ?, 561, 562, 563, 565, 566, 568, 572, 577, 578, 579, 580, 581, 582 ?, 584 ?, 592, 607, 609, 610, 612, 614 ?, 624, 625, 626, 628 ?, 633, 642 ?, 644, 646, 650, 653 ?, 656, 657, 661, 670, 671, 675, 676 ?, 678, 684, 690, 697, 705, 706 ?, 710.

Cycadeoidea insolita, Nos. 50, 64 ?

Cycadeoidea Jenneyana, Nos. 81, 87, 88, 90, 91 ?, 93, 96, 97, 98, 101, 102, 108, 109, 111, 112, 113 ?, 114, 115, 116, 120 ?, 121 ?, 124 ?, 125, 126, 171 ?, 173 ?, 174 ?, 176 ?, 192 ?, 193, 194, 195, 196, 197, 198, 199, 200, 201 ?, 202, 203, 204, 205, 206, 207, 551, 553, 555 ?, 556 ?, 558, 559, 564 ?, 567 ?, 569 ?, 570 ?, 571 ?, 573, 574 ?, 575, 576, 583, 585, 586, 587, 588, 589, 590, 591, 593, 594 ?, 595 ?, 596 ?, 597, 598, 599 ?, 600, 601 ?, 602 ?, 603 ?, 605 ?, 606, 608 ?, 613 ?, 616, 617, 618, 619, 621, 622 ?, 632 ?, 634 ?, 636 ?, 638 ?, 643, 645, 647, 648 ?, 649, 652, 654 ?, 655 ?, 658, 659, 660 ?, 663 ?, 665, 666 ?, 667 ?, 668 ?, 669, 672, 673, 674, 677, 680 ?, 681, 682 ??, 683 ?, 685 ?, 686, 688, 689 ?, 691 ?, 692 ?, 693, 694, 695, 696, 698, 699, 700, 701, 702, 703 ?, 708, 710, 721.

Cycadeoidea McBridei, Nos. 8, 19, 23, 26 ?, 27, 29 ? ?, 38, 42 ?, 46, 73, 76, 179, 180, 189 ?, 225 ?, 227, 228 ??, 231, 233 ?, 235, 245, 250, 252, 257 ?, 258 ??, 262, 268 ?, 271 ?, 288, 289, 298, 299, 301 ?, 305, 314 ?, 320 ?, 325, 326 ?, 329 ?, 338 ?, 339 ?, 340, 343 ?, 346 ?, 361 ?, 375, 379, 380, 381, 383 ?, 387 ?, 388, 407, 415, 422, 429, 431, 436 ?, 437, 439 ?, 449, 456, 462 ?, 467, 469 ?, 471, 472, 489 ?, 490, 492, 494, 495 ?, 496, 497 ?, 522 ?, 544 ?

Cycadeoidea Marshiana, Nos. 4, 9, 11, 33 ?, 44, 79 ?, 129, 143, 145, 161, 164, 167, 169 ?, 216, 219 ?, 221 ?, 256, 267, 276, 281, 283 ?, 285, 300, 392, 405, 410, 411, 418 ?, 430, 502, 541, 711.

Cycadeoidea minima, Nos. 53, 149, 150, 152, 153, 154, 155, 156, 157, 168, 426, 468, 474, 478, 714.

Cycadeoidea minnekahtensis, Nos. 14, 22, 24, 34 ?, 41, 47, 70, 71, 72, 83, 86, 140 ?, 142, 144, 148, 158, 160, 162 ?, 181, 182 ?, 184, 186 ?, 210, 211, 217, 220, 229 ?, 230, 242, 244 ?, 249 ?, 259 ?, 264, 265, 266 ?, 273 ??, 277, 279 ?, 286 ?, 290 ?, 292, 309, 310, 318 ?, 327 ?, 331, 332, 344 ?, 348 ?, 349, 350, 357, 362 ?, 365 ?, 366, 367 ?, 396 ?, 397, 401, 403 ?, 404, 412, 420 ??, 432 ?, 440, 445, 473 ?, 480, 491, 506 ?, 507, 520, 532, 533, 534, 535, 536 ?, 540, 728.

Cycadeoidea nana, No. 84.

Cycadeoidea occidentalis, No. 234.

Cycadeoidea Paynei, Nos. 52 ?, 58 ?, 69 ?. 132, 135, 163 ?, 165, 188 ?, 247 ?, 263 ?, 272, 280 ?, 284 ?, 293 ??, 316, 319 ??, 334, 336 ?, 337 ?, 364, 376, 386, 395 ?, 399, 413 ?, 423 ?, 428 ?, 434 ?, 447, 448, 451 ?, 452, 493 ?, 712, 713.

Cycadeoidea protea, Nos. 32, 185, 187, 241, 253, 296, 297, 303, 315, 359, 382, 414, 457, 458, 463, 466, 487, 499, 521, 529.

Cycadeoidea pulcherrima, Nos. 78, 159, 545.

Cycadeoidea reticulata, Nos. 254, 282, 287, 335, 342, 377, 378.

Cycadeoidea rhombica, Nos. 620, 623, 627, 629, 630, 631, 640.

Cycadeoidea Stillwelli, Nos. 16, 36, 56 ?, 105, 107 ?, 119, 175 ?, 226 ?, 515 ??, 517 ?, 552 ?, 651 ??, 662 ??

Cycadeoidea superba, Nos. 137, 146, 147, 218, 717.

Cycadeoidea turrita, Nos. 15, 35 ?, 45, 49, 51, 65, 66, 67, 74, 75, 82, 85, 139, 141, 151 ?, 166, 183, 190 ?, 191 ?, 223 ?, 255 ??, 261 ?, 269, 270 ?, 278, 295 ??, 304 ?, 313, 323, 330, 352 ?, 360, 368, 374, 394, 402, 406, 408 ?, 409, 446 ?, 450 ?, 482, 483, 484, 486, 519 ??, 731.

Cycadeoidea utopiensis, No. 727.

Cycadeoidea Wellsii, Nos. 21, 59, 130, 136, 138, 222, 243, 322, 391, 400, 500, 501, 537.

Cycadeoidea Wielandi, Nos. 77, 131, 393, 424.

Indeterminable, Nos. 31, 170, 172, 177, 178, 209, 237, 251, 260, 274, 275, 294, 302, 306, 308, 311, 312, 317, 341, 345, 347, 363, 371, 385, 389, 390, 416, 417, 419, 421, 427, 441, 442, 443, 454, 459, 460, 464, 465, 470, 475, 477, 485, 488, 514, 524, 527, 531, 604, 635, 637, 664, 679, 687, 704, 707, 709, 715.

The specimens marked as "indeterminable" are largely fragments, i. e., small pieces broken away from the trunks to which they belonged, and it is to be hoped that an exhaustive comparison with all the specimens in the collection may result in the restoration of a considerable number to the trunks now in the collection. As an aid in this work I have indicated in many cases the species to which they are most likely to belong, and given other hints as to where to look with the greatest prospect of success.

Considerable search has already been made to bring such fragments together, and it has been successful in about twenty cases. As a natural result this has changed a few of the assignments previously made and published; thus, No. 9, doubtfully referred to *C. colossalis*, proves to be a part of the trunk, No. 33, of *C. Marshiana;* No. 13, referred to *C. dacotensis*, belongs to Nos. 17 and 40, constituting a fine trunk of *C. colossalis;* No. 47, thought perhaps to be a branch of *C. Marshiana*, fits No. 142, and both together make up a good specimen of *C. minnekahtensis;* and No. 70, which resembles

C. turrita and was so referred, when joined to No. 480, to which it belongs, proves to represent *C. minnekahtensis.*

Other alterations made are as follows:

In one case, viz., that of No. 110, I have changed the assignment previously made and published in the Nineteenth Annual Report of the U. S. Geological Survey (pp. 614, 615, pls. xcix and c), referring it to *C. ingens* instead of *C. McBridei.* This change is important because this specimen was the only one from the Blackhawk region that I had referred to the latter species. After an examination of the much larger collection now in hand from that region, I am satisfied that this specimen belongs to *C. ingens*, and that *C. McBridei* is not represented in that section of the Black Hills.

The small specimen, No. 53, which I regarded (loc. cit., p. 615) as perhaps a "miniature" or "undeveloped" form of *C. McBridei*, I now make the type of a new species, *Cycadeoidea minima*, represented by 17 specimens (see infra, p. 341), and I do the same with another small specimen, No. 32, which I doubtfully referred (loc. cit., p. 608) to *C. minnekahtensis* as a dwarf representative similar to the specimen No. 19 of the U. S. National Museum. This new species is now represented by 20 specimens, all but one of which are in the Yale Museum, and may bear the name *Cycadeoidea protea* (see infra, p. 343).

After all possible assignments had been made and the indeterminable material separated out, there remained 60 specimens which, while exhibiting good specific characters, were not referable to any of the species described. These 60 specimens, however, proved to belong to very different types, and a careful classification of them shows that they constitute 7 distinct specific groups, or, in other words, 7 new species. The systematic description of these new species will therefore be our next and final task.

Cycadeoidea superba n. sp.

Trunks large (30–40^{cm} high, 30–50^{cm} in diameter, with a girth of over one meter), short-conical or somewhat globular, little compressed, unbranched; rock soft but not fragile, reddish brown, of low specific gravity; organs of the armor horizontal except near the summit where they are ascending and pass into a large terminal bud, which, however, is sometimes wanting, and a cavity, or crow's nest, occupies the summit; scars definitely arranged in spiral rows around the trunk, the angle made by the rows with the vertical axis diminishing above, those from left to right making an angle of 20–35°, those from right to left from 60–75°; leaf scars subrhombic, high in proportion to their width, the vertical angles usually

rounded, 30–40^{mm} wide, 20–25^{mm} high; leaf bases present, usually 1–3^{cm} below the surface, sometimes filling the scars or even projecting, soft, porous or spongy in structure; vascular bundles occasionally visible in a row some distance from the margin, appearing either as depressions or elevations; walls 5–8^{mm} thick, very distinct, lighter colored than the leaf bases, smooth but more or less grooved on the surface, sometimes divided by a commissure in two plates; reproductive organs numerous and well developed, sometimes tending to arrange themselves in vertical rows, raised above the surface, usually large, 4×7^{cm}, or even 6×9^{cm} in diameter, surrounded by numerous subtriangular bract scars covering much of the surface, the central portion relatively small, usually solid and amorphous, of a spongy consistency; armor 7–8^{cm} thick, obscurely attached to the axis; woody zone 5–8^{cm} thick, showing 2 or 3 rings; cortical parenchyma 3^{cm} thick; fibrous zone 3–5^{cm} thick, in one specimen consisting of two rings, the outer 12^{mm} thick, showing both longitudinal and radiate structure, the inner 8^{cm} thick, apparently subdivided into three subordinate rings; medulla 10^{cm} or more in diameter, of a homogenous structure, usually decayed at the base.

This fine species is represented in the Yale collection by 5 specimens, the numbers of which, with their weights and state of preservation, are as follows:

No. 137,	48·35	kilograms,	nearly complete.
No. 146,	45·36	"	" "
No. 147,	39·90	"	a hemisphere.
No. 218,	56·12	"	nearly complete.
No. 717,	9·75	"	incomplete.

Nos. 137 and 146 must have grown close together, as each has a flattened area near the base, and these two surfaces exactly fit together. They are, however, covered by the appressed leaf scars and had no organic attachment. Moreover, each has its own independent base and axis, and there is no proof that they were connected otherwise than mechanically. No. 147 also has some similar flattened areas, and it seems to have been the habit of this species to grow in clumps or clusters.

Its nearest affinities are with *C. McBridei*, but it differs in its globular, symmetrical form, in the more open scars, and in their smooth well-defined walls, also in the finer structure. Its next nearest relationship is with *C. Wellsii*, but it lacks the thick walls and most of the other essential features of that species.

All the specimens are from the Minnekahta region.

On Plate III may be seen side views of Nos. 137 and 146, showing also the terminal bud.

Cycadeoidea rhombica n. sp.

Trunks of medium size (40–50^{cm} high, 20–30^{cm} in diameter), subcylindrical, tapering upward, more or less laterally compressed, unbranched; rock soft on the immediate surface, hard and flinty within, reddish brown on the weathered surfaces, whitish and somewhat chalcedonized in the interior, with rather high specific gravity; organs of the armor horizontal or somewhat descending; phyllotaxy clear and well marked, the spiral rows from left to right forming an angle with the axis of 25°, those from right to left of 60°; left scars strictly rhombic with parallel sides and all angles, vertical as well as lateral, sharp, 15^{mm} wide, 9^{mm} high, and very uniform; leaf bases present usually filling the scars, square across the top but lying at different levels, rough-granular and somewhat porous, without apparent bundle scars; walls very thin, rarely 1^{mm}, consisting of a white flinty substance, the surface smooth and longitudinally grooved or pitted, often not rising to the summit of the leaf bases, thus forming cracks between them, often split into two, more or less equal, thin plates; reproductive organs present but not specially numerous or conspicuous, fairly well developed, usually projecting or forming elevations, but occasionally decayed, leaving cavities, small, 15×25^{mm} in diameter or smaller, the involucral bract scars inconspicuous, the central portion solid and amorphous externally; armor very thin, 15–20^{mm}, joined to the axis by a more or less irregular line sometimes appearing definite; woody zone about 4^{cm} thick, usually showing three distinct layers; cortical parenchyma 12–15^{mm} thick, often conspicuously marked by the thick vascular bundles passing across it and curving upward and outward to the leaf bases, its outer wall marked by shallow, longitudinal grooves, 6–10^{cm} long, pointed at their extremities, lying side by side but overlapping one another; fibrous zone in two distinct rings, the outer 10–15^{mm} thick, the inner 12^{mm} thick, separated from the outer by a definite line appearing on the fractures as a seam or crack, its inner wall also definite, both rings appearing longitudinally striate on radial fractures, but both, and especially the outer, showing on transverse fractures a radiate structure with woody wedges; medulla 6–8^{cm} thick, porous in its outer, and cherty or flinty in its inner, portion.

This is one of the best-defined species in the collection, although none of the specimens are complete. It consists of Nos. 620, 623, 627, 629, 630, 631, and 640, all from the Blackhawk region. These specimens all came in the same box with a number of others of different species (*C. Jenneyana* and *C. ingens*), and it seems probable that they were found close together. Still a comparison of them shows that they

probably represent at least three different trunks. Nos. 620 and 623 are the bases of two different trunks. Nos. 627 and 630 fit together, and Nos. 629 and 631 probably belong to that trunk. No. 640 is a small fragment clearly showing the same characters, but not known to belong to any of the other specimens.

The only affinities shown by this species with any other are with *C. Stillwelli*, and here the resemblance is confined chiefly to one specimen, No. 105, yet the scars of that specimen are not only larger but have more or less curving sides, and the leaf bases are not so squarely truncated as in these forms. It is also more strictly cylindrical. Further material may tend to assimilate these specimens; if so the effect will be to remove that specimen from *C. Stillwelli* and enlarge the scope of this species.

The specific name relates to the exactly rhombic scars. On Plate II a view of the fragment No. 629 is represented, which shows the rhombic scars to good advantage.

Cycadeoidea heliochorea n. sp.

Trunks very large, the largest probably 50^{cm}, ellipsoidal or nearly globular, flattened at the summit where a small terminal bud is set in the center of a broad surface occupied by the small, spirally arranged scars of the upper leaves, laterally compressed to an unknown extent, all the specimens probably representing the broader sides, unbranched; rock soft, reddish brown, rather fragile, of low specific gravity; organs of the armor ascending in all the specimens, but these all belong to the upper part; phyllotaxy not traceable; leaf scars obscurely shown, subrhombic or rhombic, the upper vertical angle as sharp as the lower, 25^{mm} wide and 15^{mm} high in the larger examples, diminishing to the size of bract scars; leaf bases rough and structureless, often sunk $2–3^{cm}$ below the surface, showing in a few cases faint traces of bundles in the form of projections from the bottom of the scars or ribs in the sides above the bottom; walls very thick and irregular, of the same texture as the leaf bases, presenting a rough, jagged, and uneven surface with scarcely any longitudinal arrangement or subdivision into plates; reproductive organs very numerous and prominent, nearly covering the surface to the exclusion of the leaves, usually projecting 3 or 4^{cm} as decorticated cones, sometimes absent, having fallen out, leaving deep, bowl-shaped cavities, usually large, attaining a diameter of 4×7^{cm}, but smaller ones are also common, surrounded by numerous and conspicuous, concentrically arranged, involucral bract scars, the inner bracts themselves still present forming involucres to

the projecting spadices which they invest, the central portions consisting of obovate, longitudinally striate fruits having definite and peculiar pits and markings; armor 8^{cm} thick, the leaf bases appearing to blend with the large curving vascular strands that are seen passing through the cortical parenchyma; fibrous zone and medulla not represented.

This well-marked species consists, so far as known, of the 5 fragments Nos. 722–726, collected by Mr. Wells ten miles west of Sundance in Wyoming, 90 miles northwest of the Minnekahta localities. These specimens therefore possess an especial interest from the point of view of distribution, the locality lying between the old one and the Hay Creek region from which Professor Jenney made his fine collection of fossil plants. Nos. 722–724 consist of broad portions of the armor at the upper part of three different trunks, the first two including the terminal bud and broad, flat surrounding area. No. 722 is the largest specimen, measuring 28^{cm} the longest way. They all show a curvature on both sides, which if carried all the way round would make an immense trunk. It is altogether probable that they may represent the flattened sides of much compressed trunks. It is greatly to be hoped that more material may be obtained from this locality.

The specific name, from the Greek words for sun and dance, alludes to Sundance, the only name with which the locality has been associated.

Plate IV shows the outer surface of No. 722, with the small scars spirally arranged around the small terminal bud.

Cycadeoidea utopiensis n. sp.

Trunk small (21^{cm} high, 17×22^{cm} in diameter, with a girth of 63^{cm}), irregularly short-conical, elliptical in cross section but apparently not forcibly compressed, showing one small branch and a cavity from which a second has been removed, the surface well preserved, but having an area near the summit covered by what appears to be an outer coating of ramentum as in the genus Cycadella, more or less obscuring the organs and definitely broken away on three sides including the apex; terminal bud well developed, 5^{cm} high, 7×9^{cm} in diameter, rounded towards the summit where there is a depressed area 3^{cm} in diameter occupied by small rhombic scars surrounding the somewhat projecting axis 12^{mm} in diameter; base preserved in great part, somewhat hollowed out; rock soft except the central portion which is hard and fine grained, light drab color on the surface with a somewhat calcareous appearance, but containing no lime, jet black at the center, of rather low specific gravity, weighing 8·17 kilograms; organs of the armor nearly

horizontal in the middle part of the trunk, declined near the base and progressively ascending above to the erect terminal leaves; phyllotaxy faintly traceable over some small areas near the base, indicating that the spiral rows from left to right make an angle of about 50°, and those from right to left one of about 60°, with the axis; leaf scars subrhombic, the vertical angles rounded, the upper often reduced to a curve, only those near the base normal or distinct, the rest much reduced and distorted, crowded and massed together so as to present a peculiar wrinkled and gnarly appearance, small and very narrow in proportion to their width, normal ones 2^{cm} wide, 1^{cm} high; leaf bases always present, of an open structure, with deep, variously-shaped pores separated by thin partitions, some projecting, others depressed, often showing the leaf bundles, which are arranged in a row all the way round some distance from the margin, thus appearing near the center always as large distinct pits; walls $2–5^{mm}$ thick, white, flinty and fine grained, much grooved and divided longitudinally, those of the central and upper parts of the trunk consisting of two smooth plates separated by a deep furrow, rising above and surrounding the small leaf bases so as to enclose them and form numerous shallow cups or short tubes, the whole giving to the surface a peculiar wrinkled appearance; reproductive organs common but some distance apart and not the cause of the general distortion, normal and fairly well developed, rising a little above the surface, variable in size, some having a diameter of 25×40^{mm}, others only of 15×25^{mm}, surrounded by very numerous subrhombic involucral bract scars resembling and gradually passing into the leaf scars, the central portion showing markings that represent the essential organs; armor about 25^{mm} thick, somewhat definitely joined to the axis; woody zone $3–4^{cm}$ thick, the parts incapable of being distingnished or described, but consisting in large part of loose open structure; medulla 6×10^{cm} in diameter, black within, hard and fine grained.

This species is represented by the single specimen, No. 727, purchased by Mr. Wells from a dealer in Hot Springs, who stated that it was obtained from some unknown person who claimed to have found it "50 miles west of Hot Springs in Wyoming." If the direction were due west, this point would fall in longitude 104° 30′ west from Greenwich and 12 miles west of the line of the Cretaceous border on the maps of the Black Hills. As the foot hills end about 20 miles west of Hot Springs and are succeeded here as in all parts of the Hills by the Upper Cretaceous, and these again by higher deposits, one would naturally suppose that this locality would fall far out on the Tertiary terrane. It therefore seems more probable that

the direction was northwest from Hot Springs, and this might locate it in the Lakota formation some distance north of Cambria and in the general region of the Newcastle coal field. This, could it be proved, would be interesting as supplying another link in the cycad chain which is fast encircling the Hills, and would partially close the wide gap between the Minnekahta and the Sundance regions. But, as it now stands, everything is in doubt, and it is greatly to be hoped not only that we shall ultimately learn the true locality, but that other specimens may be found. The patch of ramentum, if such it be, near the summit of the specimen raises the suspicion that it may belong to the genus Cycadella, and as all the specimens of that genus thus far known have come from the Jurassic, it is possible that the horizon of the bed holding this specimen may be lower than that of the other Black Hills cycads.

The specific name alludes to the alleged locality, which, as we have seen, would be a sort of geological nowhere.

Plate III shows a view of the best-preserved side of the specimen.

Cycadeoidea reticulata n. sp.

Trunks small (9–15^{cm} high, 10–20^{cm} in diameter, with a girth of 40–50^{cm}), globular or oblate-spheroidal, vertically compressed and also elliptical in cross section, unbranched, usually hollowed at the summit, but in one specimen showing the worn bases of the terminal leaves concentrically arranged, depressed at the base with a concave center surrounded by a groove between the armor and medulla; rock generally soft, but sometimes hard in the interior, reddish brown or lighter on the weathered surfaces, drab or dark within, of rather low specific gravity, the specimens all weighing less than 4 kilograms; organs of the armor normally horizontal; phyllotaxy more or less distinct, the rows of scars from left to right making an angle of 45°, those from right to left of 60°; leaf scars subrhombic, 15–20^{mm} wide, 6–9^{mm} high; leaf bases soft, porous or spongy, sunk 1–5^{mm} below the surface, occasionally with indistinct bundle scars near the center; walls very thin, often less than 1^{mm}, rarely exceeding 2^{mm}, hard and fine grained, presenting a smooth white surface contrasting strongly with the leaf bases, rising above them in plates or dikes or separating them with a delicate network of fine lines, thus giving the whole surface a reticulate appearance, sometimes divided by a commissure into two plates, or by two such into three; reproductive organs not abundant or conspicuous, rarely wanting, their places occupied by cavities, usually small, but variable in size, vaguely defined, averaging 15x20^{mm} in diameter, having scarcely any visible involucral bracts, the central portions porous or open, the hol-

low interior in one instance containing a collection of small round bodies of doubtful nature; armor 2–3^{cm} thick, somewhat definitely joined to the axis; woody zone 2–4^{cm} thick; cortical parenchyma 1–2^{cm} thick, generally of a loose porous structure; fibrous zone 1–2^{cm} thick in two rings, the outer thicker, dark, hard, and fine grained, the inner thin (5–7^{mm}), partitioned off by medullary septa and bounded on both sides by scalloped lines; medulla 5x8^{cm} in diameter, of a coarse and soft structure.

This species embraces 7 specimens, the numbers of which, with their weights and state of preservation, are as follows:

No. 254,	1·02 kilograms,	incomplete.
No. 282,	3·42 "	nearly complete.
No. 287,	3·86 "	"
No. 335,	3·18 "	"
No. 342,	1·25 "	incomplete.
No. 377,	3·42 "	"
No. 378,	2·61 "	"

These all came from the original Minnekahta locality. Their nearest affinities are with *C. turrita*, and they resemble certain of the branches or turrets of that species, but are all entire trunks and show no signs of branching.

The specific name refers to the reticulate appearance produced by thin white walls that form a network over the surface.

A side and top view of No. 342 are given on Plate IV. This specimen shows the leading characters as clearly as any example.

Cycadeoidea minima n. sp.

Trunks diminutive, the smallest known (6–12^{cm} high, 8–14^{cm} in diameter, with a girth of 20–39^{cm}), ovoid or obovoid, eccentric or oblique, sometimes vertically compressed or flattened at the top, simple, with a terminal bud or corresponding depression, the base usually hollowed out, but sometimes downwardly projecting; rock generally soft and porous, reddish brown or drab colored, of low specific gravity; organs of the armor horizontal except near the summit; phyllotaxy traceable in several specimens, the rows of scars from left to right making an angle with the axis that varies from 30–50°, those from right to left making an angle in all cases of 75°; leaf scars subrhombic to nearly rhombic, 15–20^{mm} wide, 7–9^{mm} high; leaf bases nearly filling the scars, sometimes rising above the walls, presenting a rough, spongy appearance, often having a pair of large pits near the center, and occasionally showing indistinct marginal rows of bundle scars; walls thin, often less than 1^{mm}, hard and flinty, light colored or white, wrinkled, striate, or grooved on

the surface, sometimes with a visible commissure; reproductive organs few and obscure, small and inconspicuous, never exceeding 3^{cm} in diameter, the bract scars very obscure and the central portion mostly solid; armor poorly exposed, 2–4^{cm} thick, separated from the axis by a somewhat definite line; woody zone 2–3^{cm} thick; cortical parenchyma 1^{cm} thick, traversed by the distinctly visible strands; fibrous zone 1–2^{cm} thick, not differentiated, somewhat definitely bounded on both walls, the outer often a scalloped surface, the inner marked by longitudinal ridges forming narrowly rhombic meshes; medulla 2–5^{cm} in diameter, porous or spongy, homogeneous and structureless.

This species embraces 15 specimens of the Yale collection and one from that of the U. S. National Museum, which are the smallest complete cycadean trunks known. The numbers, weights, and state of preservation, are as follows;

No. 53,	1·57	kilograms, complete.
No. 149,	1·22	" "
No. 150,	1·39	" "
No. 152,	0·79	" "
No. 153,	0·45	" "
No. 154,	0·45	" "
No. 155,	0·34	" "
No. 156,	0·30	" "
No. 157,	0·23	" nearly complete.
No. 168,	2·15	" complete.
No. 426,	0·30	" fragment.
No. 468,	0·45	" nearly complete.
No. 474,	0·45	" incomplete.
No. 478,	0·11	" fragment.
No. 714,	1·36	" complete.

U. S. Nat. Mus. specimen, 0·62 kilograms, nearly complete.

When I made my first study of the 87 specimens then in the Yale collection, I found No. 53 of this group, and rather than create a new species for it I doubtfully referred it to *C. McBridei*, as previously stated. Mr. Wells's next shipment, which I studied in November, 1898, contained 9 specimens so much like it that I was then certain that they constituted a specific group. The later accessions have added 5 others that belong to the same group.

In October of that year, when in the field with Mr. Wells, I picked up a small perfect specimen in the region southeast of Minnekahta station, and on account of its diminutive size I brought it back with me to Washington in my valise. It also belongs in this group. It now bears the number 2248 of the locality catalogue of fossil plants of the U. S. Geological Sur-

vey, and will form a part of the cycad collection of the U. S. National Museum. Its specific gravity is considerably higher than that of the other specimens, but beyond this there are no essential differences.

On Plate II is represented the original specimen, No. 53, which is typical of the species, but was not figured in the Nineteenth Annual Report of the U. S. Geological Survey.

Cycadeoidea protea n. sp.

Trunks small (8–12^{cm} high, 10–20^{cm} in diameter), low, sprangling, and of all shapes, often contracted at the base, the distortion probably only slightly due to compression, usually much branched, or consisting entirely of several somewhat equal systems or branches, often with a well-preserved terminal bud at the summit of each branch, usually nearly complete and little broken or worn; rock hard, firm, and fine grained, reddish brown on the surface with lighter stripes, darker within, of high specific gravity; organs of the armor wholly under the influence of the subordinate systems or branches, usually erect with reference to the terminal buds; phyllotaxy also relating wholly to the branches, around which and the often flattened summits the leaves are spirally arranged, sometimes with great regularity; leaf scars, where visible, of nearly normal subrhombic shape, but very variable in this respect due to the exuberant branching, often reduced to mere slits; very small, 6–13^{mm} wide, averaging 9^{mm}, 1–6^{mm} high, averaging 4^{mm}; leaf bases porous or showing a columnar structure but of a hard substance, usually sunk some distance below the surface, occasionally exhibiting a few large pits; walls very thin, often less than 1^{mm}, hard and flinty, of a lighter color than the leaf bases and divided into several plates the edges of which present a striate or grooved appearance, the middle plate sometimes divided by a commissure; reproductive organs small, few, and obscure, but certainly present and apparently functional, somewhat raised, 12$\times$15^{mm} in diameter, surrounded by scars that scarcely differ from the leaf scars, the central portion heterogeneous, apparently showing the ends of the essential organs; armor where exposed about 2^{cm} thick, but certain leaf bases have a length of 4–6^{cm}, joined to the axis by a somewhat definite line; wood rarely exposed, appearing about 3^{cm} thick and divided into several rings, the outermost ring (cortical parenchyma) thin, the others showing no structure, the innermost wall (exposed in one specimen) marked with broad shallow grooves terminating in pits or scars and alternating with one another; medulla of a coarse sandy consistency, contrasting

with the surrounding hard tissues, often projecting downward below the armor, varying in size with the specimen.

I have already mentioned the specimen No. 32, and the similar one No. 19 of the U. S. National Museum Collection, both of which I took for immature forms of *C. minnekahtensis*. The latest invoices contained 19 additional specimens so like these as to render that theory no longer tenable, and I feel entire confidence in erecting this large and very distinctive group into a new species. In fact, notwithstanding the anomalous character of these forms and the consequent difficulty in finding terms by which to describe them, there is scarcely a species known to me that has less confusing relationships with other species than has this one. Though truly protean, as I have attempted to imply by the specific name chosen, none of its many forms is at all the same as those of any other species.

It now consists, as we have seen, of 21 specimens, 20 of which are in the Yale collection. The numbers, with their respective weights and state of preservation, are as follows:

No. 32, 2·61 kilograms, complete.
No. 185, 0·94 " nearly complete.
No. 187, 0·14 " "
No. 241, 1·59 " "
No. 253, 1·02 " fragment.
No. 296, 1·25 " nearly complete.
No. 297, 0·34 " fragment.
No. 303, 1·59 " nearly complete.
No. 315, 0·91 " "
No. 359, 1·81 " "
No. 382, 1·25 " "
No. 414, 3·52 " "
No. 457, 1·47 " complete.
No. 458, 1·47 " incomplete.
No. 463, 0·56 " fragment.
No. 466, 0·68 " incomplete.
No. 487, 3·18 " nearly complete.
No. 499, 0·68 " " "
No. 521, 0·79 " " "
No. 529, 0·22 " " "
No. 19, U. S. Nat. Mus., 1.81 kilograms, nearly complete.

A careful study of all these specimens, and a reëxamination of No. 19 of the U. S. National Museum, have tended to strengthen the impression which the last-named specimen, considered alone, made upon my mind, and which I noted at the bottom of page 607 of my memoir on the Cretaceous Formation of the Black Hills, viz., that these small, gnarled, and branching forms have a decidedly rootlike appearance, and

suggest that the trunks, like those of the "coontie," may have developed entirely below the surface.

I have selected for illustration of this species the somewhat exceptionally regular, but still fairly characteristic specimen, No. 457, represented on Plate IV. This is a chiefly top view, showing the three nearly equal systems or branches, each with its apical scars and central bud perfectly preserved.

We now have, therefore, 29 species of fossil cycadean trunks from the Black Hills, all of which are represented in the Yale collection. To any one interested in the extinct floras of America this collection can scarcely fail to appeal in an especial manner. But we are probably only at the threshold of the subject. Not only will the raw material continue to accumulate, but as we penetrate deeper into the inner structure it is safe to predict that the results will be such as even the botanists proper cannot afford to ignore.

EXPLANATION OF PLATES.

Plate II.

No. 629.—*Cycadeoidea rhombica* Ward; type; side view. From near Blackhawk, South Dakota.

No. 53.—*Cycadeoidea minima* Ward; type; side view. Minnekahta, South Dakota.

(The numbers refer to the catalogue of the Yale Collection.)

Plate III.

No. 727.—*Cycadeoidea utopiensis* Ward; type; side view. From west of the Black Hills, Wyoming.

Nos. 137, 146.—*Cycadeoidea superba* Ward; type; side view. Minnekahta, South Dakota.

Plate IV.

No. 722.—*Cycadeoidea heliochorea* Ward; type; side view. From ten miles west of Sundance, Wyoming.

No. 342.—*Cycadeoidea reticulata* Ward; type; top view. Minnekahta, South Dakota.

No. 457.—*Cycadeoidea protea* Ward; type; top view. Minnekahta, South Dakota.

ART. XXXIV.—*On the Chemical Composition of Turquois;* by S. L. PENFIELD.

THROUGH the kindness of Mr. Ernest Schernikow of New York City, the writer has recently received a suite of turquois specimens from deposits in Los Cerillos Mts., New Mexico, and the Crescent Mining District, Lincoln Co., Nevada, and one fragment of exceptionally fine quality from the last named locality was presented with the special request that it should be used for chemical analysis. The material was very fine-grained, of a beautiful robin's-egg blue color, and broke with a smooth fracture. A thin section of the material appeared translucent and almost colorless, and when examined under the microscope, the turquois seemed to be perfectly uniform, showing no evidence of being made up of two substances, such, for example, as an aluminium phosphate, mixed with a copper salt as coloring material. The material was so fine-grained that no clue as to its crystallization could be made out, other than that it acted somewhat on polarized light. The specific gravity, taken by suspension in the heavy solution, was found to be 2·791.

In considering the chemical composition of turquois, it should be borne in mind that analyses have been made of only massive, cryptocrystalline fragments, and although they may be selected ever so carefully, no such guarantee of the purity of the material can be given as when, for example, a well crystallized mineral is analyzed. In order to show, however, that turquois is a material of nearly uniform composition, the new analysis is given below in connection with analyses made by other investigators. Analyses have not been included which show a large proportion of foreign constituents other than silica. The analyses are as follows:

	I. Lincoln Co., Nevada. Penfield.	II. Nichabour, Persia. Church.*	III. Karkaralinsk, Russia. Nicolajew.†	IV. Fresn Co., California. Moore ‡	V. Los Cerillos, New Mexico. Three analyses by Clarke.§	VI.	VII.
P_2O_5	34·18	32·86	34·42	33·21	31·96	32·86	28·63
Al_2O_3	35·03	40·19	[35·79]	35·98	39·53[b]	36·88	37·88
Fe_2O_3	1·44	2·45[a]	3 52	2 99	----	2·40	4·07
CuO	8·57	5·27	7·67	7 80	6 30	7·51	6·56
H_2O	19·38	19·34	18·60	19 98	19·80	19·60	18·49
Insol.	0·93	----	----	----	1·15	0·16	4·20
X	----	MnO ·36	----	----	CaO ·13	CaO ·38	---
	99·53	100·47	100·00	99·96	98 87	99·79	99·83
Sp. gr.	2·79	2·75	2·89	2·86		2·80	

[a] Given as 2·21 per cent FeO.

[b] Includes some Fe_2O_3.

* Chemical News, x, p. 290, 1864.
† Koksharow's Min. Russland, ix, p. 86, 1884.
‡ Zeitschr. Kryst., x, p. 247, 1884.
§ This Journal, III, xxxii, p. 212, 1886.

In the new analysis the iron was found to exist wholly in the ferric condition, and therefore the iron in Church's analysis, given as FeO in the original article, has been calculated to Fe_2O_3 to agree with the observations of the author and other investigators.

It is evident from an examination of the foregoing analyses that turquois is a material which is quite uniform in its chemical composition, so uniform in fact that it does not seem reasonable to consider it as an accidental mixture of an aluminium phosphate and a copper phosphate. The presence of the bivalent element copper, however, in somewhat variable amounts, is not so easily accounted for if we are to consider a copper phosphate as isomorphous with an aluminium phosphate. The small amount of iron is probably isomorphous with the aluminium, and it is to be expected that the iron phosphate would have little effect upon the color of the stone, for the hydrated ferric phosphate, strengite, and the hydrated ferric-arsenate, scorodite, are both light-colored minerals. The idea that the iron is present as the hydrated oxide, limonite, can scarcely be entertained.

Clarke,* in discussing the composition of turquois, states that if the alumina is combined with the phosphoric acid and water to form a molecule $2Al_2O_3.\ P_2O_5.\ 5H_2O$, there remains an excess of phosphoric acid and water which forms with the copper a salt of the composition $2CuO.\ P_2O_5.\ 4H_2O$. Turquois is considered therefore by him as consisting of variable mixtures of the foregoing salts. He regards normal turquois as the aluminium salt, $2Al_2O_3.\ P_2O_5.\ 5H_2O$, which he also expresses as $Al_2HPO_4(OH)_4$, and "the copper salt, to which the mineral owes its color, is to be considered merely as an impurity." By means of ratios it is quite easy to apply Clarke's theory to the analyses as tabulated on page 346. Taking Al and Fe as a basis, and establishing a ratio of $P : Al+Fe : H = 1 : 2 : 5$, as demanded by Clarke's formula for normal turquois, $Al_2HPO_4(OH)_4$, the ratio of *the excess of Phosphorus* : *Cu* : *the excess of Hydrogen* can then be found. The results of the calculation are as follows:

		I.	II.	III.	IV.	V.	VI.	VII.
Normal turquois, Clarke.	P	·352	·408	·373	·371	·387	·376	·396
	Al+Fe	·704	·816	·746	·742	·774	·752	·792
	H	1·760	2·040	1·865	1·855	1·935	1·880	1·980
Residues.	P	·130	·054	·111	·097	·063	·088	·008
	Cu	·108	·066	·096	·098	·080	·094	·083
	H	·394	·108	·201	·365	·365	·300	·074

* Loc. cit.

Taking copper as a basis, the ratios of P : Cu : H in the residues are as follows:

		I.	II.	III.	IV.	V.	VI.	VII.
Residues, copper as unity.	P	1·20	0·82	1·15	0·99	0·78	0·93	0·09
	Cu	1·00	1·00	1·00	1·00	1·00	1·00	1·00
	H	3·65	1·63	2·09	3·72	4·56	3·19	0·90

It is to be taken into consideration that it is a very severe test of a formula to throw all of the errors resulting from possible impurities in the materials and inaccuracies of the analyses upon a single constituent, in the case in hand on the supposed copper salt; but still the ratios of P : Cu : H are so variable that it cannot be considered that turquois is a mixture of an aluminium salt, $Al_2HPO_4(OH)_4$, and a hydrated copper phosphate having the definite composition $2CuO.\ P_2O_5.\ 4H_2O$ as suggested by Clarke. A compound having the composition $2CuO.\ P_2O_5.\ 4H_2O$ demands a ratio of P : Cu : H = 1 : 1 : 4.

An important factor to be taken into consideration is that the hydrogen in turquois is to be regarded as representing hydroxyl and not water of crystallization, for water is not expelled from the mineral at a low temperature; hence hydroxyl radicals may be considered as playing a part in the chemical composition of the mineral. Considering copper as an essential constituent of turquois and not as an impurity, two theories naturally suggest themselves: one, that the bivalent copper is isomorphous with, and replaces the bivalent aluminium-hydroxide radical $[Al(OH)]''$; the other, that the univalent copper-hydroxide radical $[Cu(OH)]'$ is isomorphous with the univalent aluminium-hydroxide radical $[Al(OH)_2]'$. The first of these ideas has led to no satisfactory solution of the problem; the second, however, reveals a constancy in the chemical relations of the mineral which can scarcely be regarded as due to accident. The relations in question are shown by combining aluminium and iron with two hydroxyls to form the groups $[Al(OH)_2]$ and $[Fe(OH)_2]$, respectively, and copper with one hydroxyl to form the group $[Cu(OH)]$, and then finding the ratio between the phosphorus and $[Al(OH)_2]' + [Fe(OH)_2]' + [Cu(OH)]' +$ Excess of hydrogen. The relations are shown by the ratios derived from the several analyses tabulated on page 346, as follows:

	I.		II.		III.	
P	·482		·462		·484	
$Al(OH)_2$	·686		·788		·702	
$Fe(OH)_2$	·018	1·450	·028	1·332	·044	1·320
$Cu(OH)$	·108		·066		·096	
H	·638		·450		·478	

	IV.		V.		VI.		VII.
P	·468		·450		·464		·404
$Al(OH)_3$	·706	·774		·722		·742	
$Fe(OH)_3$	·036	---		·030		·050	
Cu(OH)	·098	1·478	·080	1·426	·094	1·428	·083	1·262
H	·638	·572		·582		·387	

Considering $[Al(OH_2)]' + [Fe(OH)_3]' + [Cu(OH)]' + H'$ as playing the role of a univalent radical R', the ratios of P : R in the several analyses are as follows:

I,	P : R = ·482 : 1·450	= 1 : 3·01		
II,	" " = ·462 : 1·332	= 1 : 2·88		
III,	" " = ·484 : 1·320	= 1 : 2·73		
IV,	" " = ·468 : 1·478	= 1 : 3·16		
V,	" " = ·450 : 1·426	= 1 : 3·17		
VI,	" " = ·464 : 1·428	= 1 : 3·08		
VII,	" " = ·404 : 1·262	= 1 : 3·12	Average	= 1 : 3·02

The author can vouch for the purity of the material analyzed by him, as far as it is possible to do so in the case of a cryptocrystalline mineral, and can also testify as to the accuracy of the analysis, and the very close approximation to the exact ratio 1 : 3, between the phosphorus and the sum of the univalent radicals plus the hydrogen, is very suggestive. The ratios in the other analyses approximate as closely to 1 : 3 as might be expected when the character of the material is taken into consideration, and the average of all the ratios is almost exactly 1 : 3. The ratio 1 : 3 is that of phosphorus to hydrogen in ortho-phosphoric acid, H_3PO_4. Turquois may therefore be regarded as a derivative of ortho-phosphoric acid in which the hydrogen atoms are to a large extent replaced by the univalent radical $[Al(OH)_2]$, $[Fe(OH)_2]$ and [Cu(OH)]. There seems to be no fixed ratio between the radicals $[Al(OH)_2]$, $[Fe(OH)_2]$ and [Cu(OH)], nor between the sum of the hydroxyl radicals and the hydrogen. In some cases, however, there is an approximation to the ratio 2 : 1 between the sum of the hydroxyl radicals and the hydrogen, as follows:

	$[Al(OH)_2] + [Fe(OH)_2] + [Cu(OH)]$		H	
II,	·882	:	·450	= 2 : 1·02
III,	·844	:	·478	= 2 : 1·13
VII,	·875	:	·387	= 2 : 0·89

In cases like the foregoing, the composition of turquois might be considered as a mixture of an aluminium salt, $H[Al(OH)_2]_2PO_4$, with the isomorphous molecules $H[Fe(OH)_2]_2PO_4$ and $H[Cu(OH)]_2PO_4$. The molecule $H[Al(OH)_2]_2PO_4$ is equivalent to Clarke's formula for "normal turquois," $2Al_2O_3 . P_2O_5 . 5H_2O$, which he also writes $Al_2HPO_4(OH)_4$. Adopting

Clarke's suggestion that turquois contains very finely divided admixtures of iron and copper phosphates as impurities, and also his formula for the pure mineral (*normal turquois* of Clarke), Groth* expresses the composition as $PO_4Al_2(OH)_2.H_2O_2$ but suggests, however, that the formula is perhaps $PO_4H[Al.(OH)_2]$.

In conclusion it may be stated that it is the author's belief that copper and the small amounts of iron are to be regarded as constituents of turquois, rather than as impurities. In support of this idea the constant occurrence of copper, as shown by all the published analyses, may be cited. Furthermore, finely pulverized turquois is only partially dissolved by boiling in a test tube with hydrochloric acid; hence, if the material contained copper phosphate as an impurity, it would be expected that the copper phosphate would dissolve readily, leaving the basic aluminium phosphate as a pure white residue, while in tests which have been made the insoluble residues have remained blue, from beginning to end of the experiments. Considering the existence in turquois of the univalent radicals $[Al(OH)_2]$, $[Fe(OH_2]$ and $[Cu(OH)]$, the composition of the mineral, as shown by the published analyses, may be expressed as a derivative of ortho-phosphoric acid, as follows:

$$[Al(OH)_2,Fe(OH)_2,Cu(OH),H]_3PO_4.$$

The $[Al(OH)_2]$ radical always predominates, but is not present in fixed proportion. Some analyses (II, III, and VII) conform closely to the formula $[Al(OH)_2,Fe(OH)_2,Cu(OH)]_2HPO_4$.

Disregarding the iron, the calculated composition of turquois for two special cases of isomorphous replacements are given below:

$[Al(OH)_2, Cu(OH),H]_3PO_4$, $Al(OH)_2 : Cu(OH) : H = 7:1:6$.		Analysis I, page 346.	$[Al(OH)_2, Cu(OH)]_2HPO_4$, $Al(OH)_2 : Cu(OH) = 12:1$.	Analysis II, page 346.
P_2O_5	34·64	34·18	32·13	32·86
Al_2O_3	37·32	36·47[a]	42·61	42·64[a]
CuO	8·28	8·57	5·52	5·27
H_2O	19·76	19·38	19·74	19·34
	----	Insol. 0·93	----	MnO 0·36
	100·00	99·53	100·00	100·47

[a] Include the Fe_2O_3.

Considering that turquois is not a crystallized mineral, the agreement between theory and the analyses is certainly as close as could be expected.

* Tabellarische Uebersicht der Mineralien, 1898, p. 97.

Sheffield Laboratory of Mineralogy and Petrography,
Yale University, New Haven, June, 1900.

ART. XXXV. — *Quartz-muscovite rock from Belmont, Nevada; the Equivalent of the Russian Beresite;** by J. E. SPURR.

Occurrence.

THE rock which will be described in this paper occurs in a large dike just east of Belmont, the seat of Nye County, Nevada. It affords an interesting study in view of its peculiar mineralogic composition; its relation to other siliceous rocks, into which it grades in the same dike; its identity with the Russian rock, beresite; and its connection with ore deposits. The dike in which the quartz-muscovite rock is found cuts black, limy slates and gray, fine-grained, saccharoidal, crystalline limestones, which stand vertically. The formation is preeminently a slaty one and often becomes schistose, this condition being due to the metamorphism occasioned by the dike under consideration and by other connected dikes. The main dike is half a mile wide and runs in a north and south direction; on one side (the east) it is definitely bounded by the slates, but on the west these slates form only a narrow band, a few hundred yards in width, separating the dike from a large mass of coarser intrusive siliceous granite which lies west and south of Belmont. While the body of rock under consideration is technically a dike, therefore, yet it is perhaps also to be regarded as the marginal facies of the main intrusion.

Near the contact of the dike, the shaly limestones become transformed into jasperoid, as microscopic examination shows, and the development of mica has occurred along certain planes, so that the rock passes into a micaceous schist. The jasperoid itself is often schistose and contains small bunches of yellow and red metallic oxides which give it the aspect of a knotted schist (Knotenschiefer). In the unaltered slates near here Mr. Gilbert† found graptolites which mark the rocks as Silurian. According to Mr. Walcott,‡ the horizon probably corresponds with part of the Upper Pogonip formation at Eureka. In this limestone are found quartz veins which carry rich antimonial silver ores.

Composition of the Dike.

The composition of this dike is not at all uniform, although as a whole the rocks are moderately fine-grained and siliceous. The essential constituents are quartz, feldspar and white mica, but the proportions of these vary in the different localities by

* Published with the permission of the Director of the U. S. Geological Survey.
† U. S. Geographical Surveys, vol. iii, Geology, p. 180.
‡ Monograph VIII, U. S. G. S, p. 2.

the increase of one mineral to the exclusion of the others, the changes being gradual and irregular; thus in some places the rock becomes mainly quartz, in others mainly feldspar. Quartz veins are abundant, but are of irregular form and are evidently segregational, being a part of the results of crystallization contemporaneous in a general way with the crystallization of the rest of the rock; these veins often contain considerable muscovite. Biotite is sparingly present in many of the rock types observed. Only two miles to the south this great, relatively fine-grained dike runs into a mass of coarse, siliceous, biotite granite with which it is apparently continuous, although it may be that the dike is a slightly later intrusion connected with the granite. The chemical and mineralogic composition of this coarse biotite granite is much the same as those of the finer-grained dike rocks above referred to, but the texture is very different. Further south again this coarse granite is overlain by flows of massive biotite rhyolite, which has nearly the same chemical and mineralogic composition as the granite, so far as can be discerned.

It is probable that the coarse-grained granite and the rocks of the finer-grained, siliceous, variable dike above described, together with the quartz veins of the vicinity, are all nearly contemporaneous, or closely consecutive allied phenomena, representing a single period of intrusion and a single magma, the variations in composition and period of injection being due to differentiation. It is probable, also, that the similarly constituted biotite rhyolite is connected with the intrusive rocks, which may possibly represent the roots or feeders of the volcanic out-pourings.

Microscopic examination.

Biotite quartz-monzonite.—This specimen is of a type which is very abundant in the dike, particularly near its central portion. It is fine-grained and holocrystalline in the hand-specimen and contains occasional small phenocrysts of feldspar, quartz and muscovite in a granular, saccharoidal groundmass. There is a slight gneissic structure apparent in the hand specimen and the fracture follows this, but it does not appear in the thin section; it is evidently not a cataclastic phenomenon but probably a flow structure. Under the microscope the groundmass is seen to be relatively fine-grained, granular and allotromorphic. It consists of a mosaic of quartz and feldspar, with some biotite, the proportion of the different minerals being, in the order named, about 15 : 10 : 1. The feldspar is both striated and unstriated. The unstriated feldspar was determined once by the Fouqué method as labradorite-bytownite. The striated feldspars were determined in one case to be andesine;

in another, oligoclase-albite. There is probably also considerable orthoclase. The rock, therefore, appears to belong to the monzonitic family and to the quartz-monzonite group.

Siliceous muscovite-biotite granite.—This rock has in general a fine grain, like that of the quartz-monzonite just described. In general, however, it is much lighter colored than this rock, since the mica which it contains is sporadic, leaving the rest of the rock composed of quartz and feldspar. Much of the rock observed in the field contains practically no mica, so that it passes into alaskite. The specimen studied is remarkable as containing frequent bunches of pure granular quartz, about a quarter of an inch in diameter, and resembling exactly vein-quartz. In thin section the rock is seen to be in general of medium grain, while it varies locally from very coarse to very fine. The habit of the minerals is allotriomorphic granular. Just as the texture varies so enormously, so the arrangement of the constituent minerals is irregular, some areas being entirely of quartz in irregular interlocking grains, while others consist of quartz and feldspar. The feldspar is mostly untwinned and was determined as orthoclase, while some twinned feldspar was determined as albite. There are in the section occasional tiny accessory grains of muscovite and biotite, and a large broken crystal of zircon. The feldspar in one section encloses primary muscovite, while in another case the muscovite encloses quartz. This would seem to make the order of crystallization quartz, muscovite, and feldspar, but the irregular intergrowth of the whole section shows that the crystallization of all these minerals was essentially contemporaneous. The quartz and feldspar are often intergrown in micrographic fashion. The feldspar is slightly kaolinized and in places there are very small flakes of secondary muscovite, which must be held separate from the rest of the muscovite in the rock, which is plainly primary.

Quartz-muscovite rock.—This rock is the one of chief interest in the dike, and occurs in large masses. It changes gradually and irregularly into the alaskite or muscovite biotite granite above described, and from its field relations is evidently a variation of this rock. The specimen examined, which is typical, has the exact appearance of a white or light-gray, medium-grained, micaceous quartzite. It is found especially near the margins of the dike and cuts into the sedimentary slates, which are noticeably metamorphosed into jasperoid and mica-schist near the contact. Under the microscope the rock is seen to be medium-grained, with a fairly even, allotriomorphic, granular structure. The chief minerals are quartz and muscovite, the former predominant. The rock is evi-

dently what it seems to be from field relations—a variation of the alaskite or muscovite-biotite granite, the variation consisting in the substitution of muscovite for feldspar. The proportion of muscovite to quartz in this rock is such that the rock is evidently nearly a chemical equivalent of the muscovite granite. Tiny grains of feldspar are found, generally striated, and seem to be albite.

Both in the hand-specimen and in the section this rock appears perfectly fresh and all the constituents primary. The freshness of the albite particles seems to remove all question of decomposition, for there is hardly any trace of kaolinization. A more thorough investigation, however, shows that muscovite occurs in two distinct habits. In the first habit it forms large irregular grains intergrown with the quartz, and sometimes enclosing smaller grains of quartz—poikilitic structure. In the second habit it occurs either in medium-sized blades or in small sheaf-like flakes, often spherulitic in arrangement, which are intergrown with quartz grains.

Concerning the muscovite found with the first described habit there is no question as to its primary nature. The last described habit, however, suggests a secondary origin, in spite of the freshness of all the minerals of the rock. Finally, a thorough investigation has shown that these aggregates of muscovite and quartz are plainly derived from orthoclase, some fragments of which may yet be found in the midst, with blades of muscovite and quartz grains penetrating them. It is plain that the alteration of the feldspars has been confined to the orthoclase and has not attacked the albite, which remains fresh.

The amount of primary orthoclase which the aggregates of secondary muscovite and quartz represent is so considerable as to put the primary rock among the fine-grained muscovite granites and to make it almost exactly similar to the muscovite granite just described, with which it is so closely connected in the field.

Biotite granite.—The biotite granite, into which this great fine-grained dike appears to merge south of Belmont, may be briefly described. The rock is porphyritic, carrying numerous crystals of orthoclase up to two inches in length. Under the microscope these orthoclase crystals are found to be intergrown with shreds of orthoclase differently oriented from the main crystal, but uniformly oriented among themselves. The crystals also contain shreds of muscovite. The groundmass is very coarse, and is remarkable for containing blotches of pure quartz in granular aggregates similar to that described above for the fine-grained muscovite-biotite granite of the great dike. In this case the blotches of quartz are from one-third of an inch to one-half an inch in diameter, and each

consists of a mosaic of intergrown grains. Besides this quartz, the groundmass consists of an allotriomorphic, granular intergrowth of quartz and feldspar, with subordinate biotite. The feldspar is mostly orthoclase. A faintly striated feldspar was determined to be anorthoclase, or microcline-anorthoclase. The feldspars sometimes show zonal structure.

Differentiation of the Great Dike.

This has not been carefully studied, but in general the darker colored rock, which has been shown in one specimen to be a quartz-monzonite, occupies the central portion of the dike, while the rock near the margin consists of the siliceous muscovite granite, or quartz-muscovite rock. This seems to indicate, at this locality at least, that the borders of the dike are more siliceous than the center.

Origin of Quartz-muscovite rock and connection with ores.

Although the quartz-muscovite rock is evidently a product of alteration, yet it is not due to surface weathering, since the condition of the rock is quite fresh and hard, and the albite shows no trace of decomposition. The process must be regarded as one of endomorphism and as connected and probably contemporaneous with the exomorphism indicated by the alteration of the siliceous limestone of the wall-rocks to jasperoid and mica schist. In both the intrusive and the intruded rock the result of the metamorphism has been the same, producing quartz and muscovite at the expense of the orthoclase on the one hand, and of the calcite and subordinate minerals on the other. In the case of the wall-rock the metamorphism, being apparently from its distribution dependent upon the intrusion, evidently took place after this intrusion and was brought about by the solutions which accompanied the igneous rock, or were residual from its solidification. Within the dike the similar alteration was probably contemporaneous with that in the country rock.

In the immediate vicinity of this intrusive mass are ore deposits, which in the time of Nevada's prosperity made this region one of considerable wealth, although at present the mining industry is perfectly dormant. The writer had not opportunity to study these, but according to Mr. Emmons* the ores generally occur in white quartz veins which are often several feet in width. These quartz veins are probably contemporaneous with those already described as occurring in irregular form within the dike rock itself, and as evidently rep-

*Geological Explorations of the 40th Parallel Mining Industry, vol. iii, p. 393.

resenting the final product of the residual solution of the general magma. In these quartz veins the metallic minerals are scattered in bunches or disseminated particles, rarely in banded form. These metallic minerals consist principally of stetefeldtite, which is an argentiferous ore of antimony, containing besides silver, lead, copper and iron. Dana* notes that this mineral in Peru has been regarded as probably arising from the decomposition of chalcostibite, a sulphide of antimony and copper. Chalcostibite occurs at Wolfsberg in the Hartz in nests embedded in quartz.

The metallic minerals being, from their habit, plainly contemporaneous with the quartz veins which enclose them, it is evident that the deposition of these minerals, the formation of the quartz veins, the metamorphism of the country-rock to jasperoid and muscovite schist, and the endomorphism of the muscovite granite to quartz-muscovite rock were contemporaneous occurrences, all brought about by the same agencies, which were the solutions representing the end product of the differentiation of the granitic intrusive rock.

The identity of the quartz-muscovite rock with the beresite of Russia.

The rock called beresite occurs in the vicinity of Beresovsk in the Urals, where it is intimately connected with veins of auriferous quartz. The beresite itself forms distinct dikes, varying from two to twenty meters, and reaching forty meters in width. These veins have a general north and south direction, but vary locally and interlace. They were first described by G. Rose† in 1837. He describes the constituents of the rock as orthoclase, plagioclase, quartz, and muscovite in exceedingly varying proportions. The feldspar diminishes and often completely disappears, leaving the rock composed of quartz and muscovite. Some varieties are like sericite schists; others like micaceous sandstones. Rutile is occasionally found as accessory. Rose was inclined to regard the Beresovsk veins as apophyses from the neighboring granite of Schartassh,‡ which is a fine-grained rock of semiporphyritic nature consisting chiefly of quartz and feldspar (the latter in part albite), with small flakes of biotite. The exact relation of the beresite to the neighboring granite, however, has not been ascertained.§ The beresite is intrusive into vertical or highly dipping schistose strata, either chloritic (listvenites), or talcose and argillaceous.

* System of Mineralogy, sixth edition, 1896, p. 204.
† Reise nach dem. Ural, vol. i, p. 186; vol. ii, p. 557.
‡ Op. cit., vol. i, p. 189.
§ Op. cit., vol. ii, p. 559.

These schists strike north and south parallel to the beresite dikes; they often contain serpentine. The beresite had been so named by the miners of the district previous to Rose's investigation, and had been hunted for as the surest index to gold. The dikes are cut obliquely by highly inclined or vertical auriferous quartz veins. Ordinarily these veins do not extend beyond the beresite, but sometimes they enter the country-rock, and even extend to the next dike. The beresite itself, where it consists chiefly of quartz, muscovite and pyrite, notably near the river Tchéremchanka, contains, according to the researches of A. Sokolow, 50 drachms of gold to the ton. Rarely, native gold has been found in it.* A peculiarity of the beresite, which makes it difficult of investigation, is its profound decomposition, fresh portions being very rarely met with. In the upper horizons it is often altered to a light colored clayey mass, while the neighboring schists of the country-rock are altered to a red clay.

After the thorough description of beresite by Rose no other studies were made until Karpinsky published his results in 1876.† Karpinsky investigated what appeared to him to be fresh pieces of the beresite, and these showed themselves to be free from feldspar and to be composed of muscovite and quartz, with a little iron-pyrite. He came to the conclusion that the beresite is a feldspar-free rock, and, contrary to Rose's opinion, not to be connected with granite. In his second paper, Karpinsky admitted that orthoclase is present in beresite from another locality, and separated the rock into a feldspar-free and a feldspar-bearing variety, which are connected with one another by transitions. Besides the beresites at Beresovsk, a number of other Russian localities have been described by Rose,‡ while Karpinsky and Arzruni§ have added still others.

What appears to be the most thorough and clear-sighted study of the beresite was made in 1885 by Arzruni.‖ He describes the beresite as a fine-grained dike-rock of coarser or finer texture and often semi-porphyritic structure, the varieties of this rock being so varied in their peculiarities that it seems proper to describe the different occurrences separately. By the diminishing of one or the other of the mineral constituents, such as the feldspar or the mica, special types are presented.

* A. Karpinsky, Guide des Excursions du VII Congrés Geologique International, No. 5, p. 41.

† Protocol of the Geologic-Mineralogic section of the Natural Science Society at St. Petersburg meeting on the 3d of May, 1875, and on the 9th of September, 1876. German summary of the Russian text given by Arzruni, Zeitschr. d. Deutsch. Geolog. Gesell., vol. xxxvii, 1885, p. 867.

‡ Reise, etc., vol. i, pp. 294, 302, 321, 436; vol. ii, pp. 34, 36, and 557.

§ Zeitschr. d. Deutsch. Geolog. Gesell., vol. xxxvii, 1885, p. 870.

‖ Op. cit., pp. 865–896.

Arzruni found, however, that those beresites which consist entirely of quartz and muscovite, and which had been regarded by Karpinsky as fresh feldspar-free rocks, actually contained feldspar in their original condition, although the feldspar has undergone a complete transition to mica and quartz. It appears, also, that the alteration has affected only the orthoclase, while the plagioclase has remained unaltered. Since in the different parts of the rock the relative proportion of orthoclase and plagioclase is very variable, it results that the varieties rich in plagioclase contain feldspar, even when the orthoclase is altered to quartz and muscovite, while the varieties poor or lacking in plagioclase can reach a transitional stage where they can be regarded as feldspar-free beresites. As the result of the study Arzruni concludes that beresite is a genuine muscovite granite with a tolerably constant mineralogic constitution.

The rocks described from Belmont are identical in nearly every particular with those of Beresovsk, except that in Belmont the decomposition has not affected the rocks to any extent, permitting a much more accurate study.

Analysis of Belmont rock.

A sample of the quartz-muscovite rock from Belmont proved to have the following composition:

Analyst, Dr. H. N. Stokes.

SiO_2	84·15
Al_2O_3	9·67
Fe_2O_3	·51
FeO	·07
MgO	·04
CaO	·53
Na_2O	2·65
K_2O	1·57
H_2O-	·21
H_2O+	·74
TiO_2	trace
F	·02
MnO	trace
SrO	trace
	100·14

A rough computation of this analysis shows the proportion by weight of albite to muscovite to be about 5 : 6. The specimen then is one which contains much more unaltered feldspar than some of the other varieties. Those varieties which originally contained orthoclase, but no albite, would now be rocks free from feldspar.

Art. XXXVI.—*The Volumetric Estimation of Copper as the Oxalate, with Separation from Cadmium, Arsenic, Tin, and Zinc;* by Charles A. Peters.

[Contributions from the Kent Chemical Laboratory of Yale University—XCVIII.]

It is a well known fact that copper oxalate is insoluble in water and scarcely attacked by moderate amounts of dilute nitric acid.* Upon this fact Bournemann† has recently based a method for the separation of copper from cadmium by precipitating copper as the oxalate in the presence of nitric acid, filtering hot, and estimating the copper after ignition, by any of the well known gravimetric methods. Six to ten grams of copper, as the oxide, were used for a single determination, and the errors were large. Bournemann does not recommend this process as an accurate analytical method. Classen‡ describes a method for the separation of metals as oxalates by adding to the solution of the salt of the metals a dilute solution of the potassium oxalate (1 : 6) and concentrated acetic acid to 80 per cent of the total volume. Regarding copper salts in particular, Classen states that precipitation takes place only in dilute solution and then not completely.

It has been the experience of the writer, that the precipitation of copper oxalate from solutions containing at least 0·0128 gm. of the oxide and saturated with the oxalic acid is practically complete. The filtrate in such cases gives no blue color with ammonia, looking down on a column of liquid in a test tube, and only a faint brown color is developed when the filtrate is neutralized, made acid with acetic acid, and tested with potassium ferrocyanide. It is the object of this paper to show that moderate amounts of copper may be determined quantitatively as the oxalate by precipitation with oxalic acid and titration of the precipitate by potassium permanganate, and also to show that moderate amounts of copper may be separated from other metals in the presence of nitric acid, by the addition of considerable amounts of oxalic acid.

Before attempting the quantitative separation of copper from solution by the addition of oxalic acid a few qualitative experiments upon the precipitation of varying amounts of copper sulphate by varying amounts of oxalic acid were tried at different dilutions. In all the experiments the mixtures stood 16–20 hours, and were filtered from 2 to 4 times through four filters folded together, and the filtrates were tested

* Storer, Dictionary of Chemical Solubilities, p. 463.
† Chem. Ztg., xxiii, 565.
‡ Ber., x, b, 1316.

both with ammonia and with potassium ferrocyanide. In cases where the filtrate gave no blue color with ammonia and only a slight precipitate with ferrocyanide the precipitation was considered practically complete and the conditions were regarded suitable for the trial of the method quantitatively. In the following table is recorded the work upon the precipitation of copper sulphate by 0·5 gm., 1·0 gm., and 2·0 gms. of oxalic acid in 50$^{cm^3}$ of solution.

TABLE I.

Dilution 50$^{cm^3}$.

	CuO taken as $CuSO_4$ gms.	Oxalic acid added in solution. Filtrate treated with NH_4OH	Oxalic acid added in solution. Filtrate treated with $K_4FeC_6N_6$	Oxalic acid added in crystalline form. Filtrated with NH_4OH	Oxalic acid added in crystalline form. Filtrate treated with $K_4FeC_6N_6$
2·0 gms. oxalic acid present.	0·018	blue color	abundant ppt.	blue color	abundant ppt.
	0·031	trace "	" "	trace "	evident "
	0·051	-------	evident "	-------	" "
	0·064	-------	trace "	-------	trace "
1·0 gm. oxalic acid present.	0·018	blue color	abundant ppt.	blue color	abundant ppt.
	0·031	"	" "	trace "	evident "
	0·051	trace "	" "	-------	" "
	0·064	-------	evident "	-------	" "
	0·094	-------	trace "	-------	trace "
0·5 gm. oxalic acid. present.	0·018	blue color	abundant ppt.	blue color	abundant ppt.
	0·031	"	" "	trace "	" "
	0·051	trace "	" "	-------	evident "
	0·064	-------	evident "	-------	trace "
	0·094	-------	trace "	-------	" "

It will be seen readily by comparison of the right and left hand sides of the table above that somewhat smaller amounts of copper may be precipitated completely by the addition of crystallized oxalic acid than by the same amount of oxalic acid already in solution. Thus, when dissolved oxalic acid is added to the solution of 50$^{cm^3}$ amounts of copper sulphate less than 0·040–0·050 gm. are not precipitated completely, while under conditions otherwise the same excepting that the oxalic acid is added in crystalline form, the precipitation of amounts as small as 0·030 gm. is practically complete. The amount of oxalic acid in solution necessary for the complete precipitation (after 16 to 20 hours) of this minimum amount of copper, 0·031 gm. of copper oxide taken as the sulphate, appears, as shown in Table II, A, which follows, to be about 3·5 gms. in 50·0$^{cm^3}$. If the amount of oxalic acid is increased to 5 gms., making the solution saturated for that substance, using the

same volume of liquid, the minimum amount completely precipitable is reduced to 0·0128 gms. but not to one-half that amount.

TABLE II.

CuO taken as $CuSO_4$ gms.	Oxalic acid added in solution. gms.	Volume at precipitation. cm^3.	Filtrate treated with NH_4OH.	Filtrate treated with $K_4FeC_6N_6$.
		A		
0·031	0·5	50	blue color	abundant ppt.
"	1·0	"	"	" "
"	2·0	"	trace "	" "
"	3·0	"	slight " "	" "
"	3·5	"	--------	evident "
0·0128	5·0	"	no blue	trace "
0·0064	5·0	"	blue color	abundant "
		B		
0·0064	0·5	20	faint blue	abundant ppt.
"	"	15	"	" "
"	"	10	"	faint "
"	"	5	--------	trace "
0·0003	0·5	5*	--------	--------
"	0·1	1†	--------	--------

It appears from the experiments of Table II, B, that the volume of liquid in which precipitation takes place influences the complete precipitation of the copper oxalate. Thus the precipitation of 0·0064 gm. of copper oxide taken as the sulphate by 0·5 gm. of oxalic acid is complete in 5^{cm^3} of liquid. The precipitate which falls from 0·0003 gm. of the oxide taken as the sulphate dissolves in 5^{cm^3} of liquid, but remains visible in 1^{cm^3}.

As a result of the preliminary experiments, it may be said that the presence of a certain minimum amount of copper, varying with the conditions, is essential to complete precipitation. Thus, at a dilution of 50^{cm^3} a saturated solution of oxalic acid will precipitate with practical completeness copper taken as the sulphate in amounts exceeding the equivalent of 0·0128 gm. of copper oxide; that 2·0 gms. of oxalic acid will precipitate almost completely for the same volume of solution the equivalent of 0·03 gm. of copper oxide; and that 1·0 gm. or 0·5 gm. of oxalic acid will precipitate the equivalent of 0·064 gm. of the oxide.

In the quantitative separation of copper as the oxalate the method of treatment was in general as follows. Copper sul-

* Precipitate redissolved.
† Precipitate remained.

phate in 50$^{cm^3}$ of water was thrown down by the addition of dry oxalic acid to the hot solution, and, after standing over night, the precipitate was filtered on asbestos, washed two or three times with small amounts of cold water. The precipitate, still in the crucible, was returned to the beaker in which precipitation took place, 5 or 10$^{cm^3}$ of dilute sulphuric acid (1 : 1) were then added together with a convenient amount of water, and, after heating the liquid to boiling, the oxalic acid was titrated with permanganate, the oxalate of copper dissolving readily as fast as the excess of oxalic acid is removed by the permanganate. The precipitate may also be dissolved in 10$^{cm^3}$ of strong hydrochloric acid,* 0·5 gm. manganous chloride added and titrated at 30°–50°. Experiments 4 and 5 were conducted after this manner. In Table III, A, which follows, are recorded results of the quantitative tests of the method.

TABLE III.

	CuO taken as $CuSO_4$. gms.	Oxalic acid. gms.	Volume at precipitation. cm^3.	CuO found. gms.	Error. gms.
			A		
1	0·0372	0·15	100	0·0286	−0·0086
2	0·1860	0·50	125	0·1831	−0·0029
3	0·0398	"	50	0·0376	−0·0022
4	0·1860	1·0	150	0·1834	−0·0026
5	"	0·5	50	0·1864	+0·0004
6	"	"	"	0·1866	+0·0006
7	"	"	"	0·1866	+0·0006
8	"	1·0	"	0·1866	+0·0006
9	0·0398	"	"	0·0391	−0·0007

In experiments 1–4, deficiencies are found in the amounts of oxalate precipitated at different degrees of dilution and by different amounts of the precipitant which are in agreement with the results obtained in the preliminary work; the results of experiments 5–9, in which 0·5 grm. and 1·0 grm. of oxalic acid act in a total volume of 50$^{cm^3}$, show the precipitation to be essentially complete under these conditions.

To study the insolubility of the copper oxalate in nitric acid the experiments in Section B of the table were made.

In experiments 10–13 amounts of oxalic acid varying from 0·5 gm. to 3·0 gms. appear to precipitate the copper completely in the presence of 5$^{cm^3}$ of strong nitric acid. In experiment 14 the amount of oxalic acid used was not sufficient to throw down all the copper in the presence of 10$^{cm^3}$ of nitric acid, but

* Gooch and Peters, this Journal, vii, 461, 1899.

TABLE III (continued).

	CuO taken as $CuSO_4$. gms.	Oxalic acid. gms.	HNO_3 sp. gr. 1·40. cm^3.	Volume at precipitation. cm^3.	CuO found. gms.	Error. gms.
			B			
10	0·1860	0·5	5·0	55	0·1859	−0·0001
11	"	"	"	"	0·1860	±0·0000
12	0·1990	2·0	"	"	0·1989	−0·0001
13	"	3·0	"	"	0·1990	±0·0000
14	"	2·0	10·0	60	0·1971	−0·0019
15	"	3·0	"	"	0·1987	−0·0003
16	"	"	"	"	0·1985	−0·0005
17	"	5·0	12·0	130	0·1977	−0·0013
18	"	"	"	"	0·1975	−0·0015
19	"	"	25·0	"	0·1837	−0·0153
20	"	"	"	"	0·1831	−0·0159
21	"	"	5·0	"	0·1983	−0·0007
22	"	"	"	"	0·1988	−0·0002
			C			
23	"	2·5	5·0*	65	0·1971	−0·0029
24	"	2·0	"	"	0·1981	−0·0019

the copper does come down completely in the presence of the large amount of the nitric acid upon the addition of more oxalic acid, as seen in experiments 15 and 16. In experiments 17 and 18 with a larger volume of water and a larger absolute amount, though approximately the same percentage, of nitric acid present as in experiments 10–13, there is a slight loss of copper; but in experiments 21 and 22 when the amount of nitric acid is reduced to 5^{cm^3} in the larger total volume the results are normal. Experiments 19 and 20 show the increased loss when still larger amounts of nitric are present. These facts would make it seem best to limit the absolute amount of nitric in solution to about 5^{cm^3}.

One observation may well be noted here; namely, that while one-half gram oxalic acid is all that is needed for the complete precipitation of the copper in the presence of 5^{cm^3} strong nitric acid, still the oxalic acid may be added up to the point of saturation of the solution. More than this causes difficulty owing to the fact that a large amount of water is necessary to wash the precipitated oxalate. About 2·0 gms. of oxalic acid to 50^{cm^3} of water is a convenient proportion.

In experiments 23 and 24, 5^{cm^3} of nitric acid were neutralized with ammonium hydroxide before adding the 5^{cm^3} strong

* About 9 gms. of ammonium nitrate present in addition to the 5^{cm^3} of nitric acid.

nitric acid in excess. The results show the solubility of copper oxalate in ammonium nitrate and exclude the possibility of such a procedure in this work.

Some experiments were made to show the time necessary for the complete precipitation, both in the presence and absence of nitric acid. Following is the record of such work.

TABLE III (continued).

	CuO taken as $CuSO_4$. gms.	Oxalic acid. gms.	HNO_3 sp. gr. 1·40. cm^3.	Volume at precipitation. cm^3.	CuO found. gms.	Error. gms.	Details of filtration.
				D			
23	0·1990	2·0	....	50	0·1984	−0·0006	Filtered hot immediately
24	0·2030	"	....	"	0·2025	−0·0005	Filtered hot immediately
25	0·1990	1·0	....	"	0·1990	±0·0000	Filtered after cooling; stood 15 minutes
26	"	"	....	"	0·1987	−0·0003	Filtered after cooling; stood 15 minutes
				E			
27	"	2·0	5·0	55	0·1943	−0·0047	Filtered after cooling; stood 15 minutes
28	"	"	"	"	0·1969	−0·0021	Stood 2½ hours
29	"	"	"	"	0·1973	−0·0017	Stood 6 hours
30	"	"	"	"	0·1989	−0·0001	Stood 16 hours

The results in section D would seem to show that a solution containing copper may be precipitated hot as the oxalate and filtered either hot or after cooling with a very slight loss. Tests of the filtrates made with potassium ferro-cyanide confirmed these results. When nitric acid is present, however, the mixture must stand after the addition of the precipitant. In section E the gradual decrease of the minus error is noticed, as the time of standing is extended, the precipitation being practically complete upon standing over night.

Separation from Cadmium.

Bournemann* has used nitric acid for a rough separation of copper from cadmium. This method was tried for a quantitative separation in the presence of 6–10 per cent strong nitric acid. The results are found in section F of the table to follow.

* Loc. cit.

Experiments 33–35 stood six hours before filtering. Experiments 36 and 37 stood over night. Copper is separated from more than twice its weight of cadmium, and the results are accurate.

Separation from Arsenic, in Both Conditions of Oxidation.

For the separation from arsenic, arsenious oxide dissolved in sodium carbonate, and di-hydrogen sodium arseniate were the forms of arsenic used. The results are accurate and are given in sections G and H of the table. In experiments 38–40 and 44 and 45 no nitric acid was added. While the presence of the nitric acid is not necessary for the separation of the copper from the arsenic; still the filtration in the absence of the nitric acid is so slow as to be objectionable. The presence of the nitric acid causes the precipitate to come down in a coarser condition, and in such condition it filters easily and is capable of being washed quickly.

Separation from Tin, in Both Conditions of Oxidation.

For the separation of copper from tin a preparation of stannous chloride (20^{cm^3} giving 0·3746 gm. metallic tin by the battery) containing sufficient hydrochloric acid to prevent deposition of oxy-salts was used. The solution of stannic chloride contained 1·0 gm. metallic tin to every 10^{cm^3}, and was used without hydrochloric acid. The results of the work are found in sections I and K of the table. The experiments go to show that while copper may be separated from small amounts of tin as stannous chloride yet there is a limit to the amount of tin which may be present. One-tenth of a gram of metallic tin is the largest amount that can be present, with 0·15 gm. copper oxide taken as the sulphate, without significant error. Practically the same statement can be made of the separation of copper from tin taken as stannic chloride. Experiment 57 shows a greater loss of copper when the nitric acid is omitted.

Separation of Copper from Iron.

A solution of ferric nitrate was used for the work on the separation of copper from iron. Low results were obtained when a solution of ferrous or ferric sulphate was used as the source of iron. The results of the experiments are recorded in section L of the table, and show that 0·20 gm. copper oxide as the sulphate may be separated from 0·2–0·3 gm. iron oxide taken as the nitrate. In experiment 64 a good result was obtained when no nitric acid was present, save that added in combination with the iron. A comparison of experiments 63 and 65 shows that it is best to avoid the use of large amounts

TABLE III (continued).

	CuO taken as $CuSO_4$. gms.	Element from which copper was separated. gms.	Oxalic acid. gms.	HNO_3 sp. gr. 1·40. cm^3.	Volume at precipitation. cm^3.	CuO found. gms.	Error. gms.
		CdO taken as $CdSO_4$.		F			
33	0·1990	0·10	2·0	5·0	60	0·1983	−0·0007
34	"	0·20	"	"	65	0·1987	−0·0003
35	"	0·30	"	"	70	0·1987	−0·0003
36	"	0·40	"	"	75	0·1994	+0·0004
37	"	0·50	"	"	80	0·1996	+0·0006
		As_2O_3 taken as Na_3AsO_3.		G			
38	"	0·10	"	----	55	0·1991	+0·0001
39	"	0·20	"	----	60	0·1987	−0·0003
40	"	0·50	"	----	75	0·1986	−0·0004
41	"	0·10	"	5·0	60	0·1994	+0·0004
42	"	0·20	"	"	75	0·1992	+0·0002
43	"	0·60	"	"	85	0·1995	+0·0005
		As_2O_5 taken as H_2KAsO_4.		H			
44	"	0·10	"	----	60	0·1985	−0·0005
45	"	0·20	"	----	70	0·1990	±0·0000
46	"	0·10	"	5·0	65	0·1990	±0·0000
47	"	0·20	"	"	75	0·1992	+0·0002
48	"	0·30	"	"	85	0·1985	−0·0005
49	0·2030	0·30	3·0	"	85	0·2026	−0·0004
	Cu taken as $CuSO_4$.	Sn taken as $SnCl_2$ + HCl.		I		Cu found.	
50	0·1590	0·0468	2·0	5·0	55	0·1581	−0·0009
51	"	0·0936	"	"	60	0·1603	+0·0013
51*a*	"	"	"	"	"	0·1591	+0·0001
52	"	"	"	"	"	0·1594	+0·0004
53	"	0·1873	"	"	65	0·1603	+0·0013
54	"	0·2809	"	"	70	0·1914	+0·0324
55	"	"	3·0	"	75	0·1988	+0·0398
		Sn taken as $SnCl_4$.		K			
56	"	0·10	2·0	"	55	0·1581	−0·0009
57	"	0·10	"	----	"	0·1565	−0·0025
58	"	0·20	"	5·0	"	0·1577	−0·0013
59	"	0·50	"	"	60	0·1562	−0·0028
	CuO taken as $CuSO_4$.	Fe_2O_3 taken as $Fe(NO_3)_3$.		L		CuO found.	
60	0·1990	0·136	2·0	5·0	60	0·1987	−0·0003
61	"	0·272	"	"	"	0·1983	−0·0007
62	"	0·364	"	"	"	0·1988	−0·0002
63	"	0·544	"	"	65	0·1971	−0·0019
64	"	0·272	"	----	60	0·1995	+0·0005
65	"	0·544	"	2·0	"	0·1998	+0·0008
66	"	0·218	"	"	65	0·1999	+0·0009
		ZnO taken as $ZnSO_4$.		M			
67	"	0·028	"	5·0	60	0·2007	+0·0017
68	"	0·057	"	"	65	0·2008	+0·0018
69	"	"	"	"	"	0·2008	+0·0018
70	"	0·085	"	"	70	0·2035	+0·0045

of nitric acid when the larger amounts of ferric nitrate are present.

For a practical application of the above separation of copper from iron a convenient amount of finely ground chalcopyrite (0·5 gm.) was roasted 2–3 hours in a porcelain crucible until all sulphur was driven off, washed into a beaker, strong nitric acid about 5^{cm^3} was added and, with the beaker covered, allowed to evaporate slowly on a hot plate, nearly to dryness. A little dilute nitric acid was added, the solution was filtered, the residue was washed with water containing dilute nitric acid, the filtrate, about 50^{cm^3} in volume, was precipitated with 2·0 gms. oxalic acid, and the precipitate was estimated after standing 12–16 hours, as previously described. The washing with water acidified with nitric acid is important because the finely ground ferric oxide remaining undissolved passes through the filter when washed with water alone, but gives no trouble if the water be acidic. The results of two estimations are here given.

Chalcopyrite. gms.	Copper found by battery.	Copper found by oxalate method.	Difference.
0·5000	31·00%	30·92%	−0·08%
1·0000	"	31·25	+0·25

Separation of Copper from Zinc.

The separation of copper from zinc was not altogether successful owing to the tendency of the zinc oxalate to come down with the copper oxalate. Some experiments are given in section M of the table.

The separations of copper from bismuth and antimony were unsuccessful.

The work may be briefly summarized as follows: Copper exceeding in amount the equivalent of 0·0128 gm. of the oxide to 50^{cm^3} of solution as the sulphate may be separated completely, even in the presence of a moderate amount of strong nitric, by the addition of sufficient amount of oxalic acid.

Copper may be separated from cadmium, arsenic, iron, and small amounts of tin, when precipitated by oxalic acid in a volume of $50·0^{cm^3}$ containing 5^{cm^3} strong nitric acid. Inasmuch as the completeness of precipitation of the copper depends upon the presence of a certain minimum amount of the copper salt this method is not applicable when the amount of copper falls below 0·0128 gm. of the oxide to 50^{cm^3} of solution.

The author wishes to thank Professor F. A. Gooch for much kind help given in the preparation of this paper.

ART. XXXVII.—*Synopsis of the Collections of Invertebrate fossils made by the Princeton Expedition to Southern Patagonia;* by Dr. A. E. ORTMANN.

IN the February number (1900) of this Journal, Mr. J. B. Hatcher has given a general account of the sedimentary rocks of Southern Patagonia, frequently (pp. 98, 101–104, 108) referring to the present writer's studies on the fossils of this region. Since these studies have now come to an end, it seems well to give a preliminary report on the chief results obtained, in order to give an idea of the richness of the material at hand, and to enable the scientific public to get a more correct understanding of the beds in question than has hitherto been possible. A final report on the Tertiary Paleontology of Southern Patagonia will be given by the writer in a volume of the "Princeton Expedition to Patagonia," which is in course of preparation, and will be freely illustrated by figures of all species represented, drawn by Mr. F. van Iterson. It is hoped that this volume will be ready by the end of this year or the beginning of next.

The present article is intended to treat only of the so-called "Patagonian formation." As Mr. Hatcher has already pointed out (l. c., p. 101), we have sufficient reason to believe, that the different marine horizons distinguished by F. Ameghino and accepted—at least in part—by H. von Ihering (the Patagonian formation, divided into a "Piso Juliense" and "Piso Leonense," and Suprapatagonian beds or lower part of the Santa-Cruz-formation) are identical, i. e., belong in one and the same continuous series of marine deposits underlying the Mammiferous Santa-Cruz-formation, and we retain the old term *Patagonian formation* for this series, which is certainly a paleontological unit, and belongs, as the writer is now fully satisfied, in the *Lower Miocene.* The fauna of this series is represented in our collection by over 140 species, many of which are new to science.

I shall give here first a list of the *new species*, with short diagnoses and other remarks that are necessary to recognize them, and then I shall add a list of species known from other localities, but *not found previously in Patagonia*, and shall conclude this article by some remarks on the *synonymy*, etc., of known Patagonian forms.

Diagnoses of new species from the Patagonian formation.

ECHINODERMATA.

1. *Cidaris antarctica* sp. nov. Plates with a moderately large, perforated central tubercle, the neck of which is slightly crenulated. Scrobicule large, surrounded by a circle of small tubercles, between which there are still smaller ones. Spines subcylindrical, often slightly compressed, neck somewhat constricted. Articular surface finely striated, with a deep articular groove. Surface of spines closely covered with fine, rounded granules, forming irregular longitudinal rows.

Only isolated spines and plates, San Julian, Santa Cruz, Upper Rio Chalia, Lake Pueyrredon.

2. *Toxopneustes præcursor* sp. nov. Test suborbicular. Ambulacral and interambulacral spaces with 4–8 vertical rows of tubercles of subequal size, those of the ambulacral spaces being somewhat smaller. Poriferous zone moderately broad. Pores in three pairs, the two outer vertical rows separated from the inner row by a small tubercle. All the primary tubercles surrounded by small secondaries and miliaries. Actinostome sunken, and lower surface concave, the actinal cuts comparatively slight.

This species differs from the known recent species of *Toxopneustes* chiefly in the more crowded tubercles. The most closely allied form seems to be: *T. pileolus* (Lmck.).

San Julian; Shell Gap (Upper Rio Chico).

3. *Cyrtoma posthumum* sp. nov. Test subcircular-elliptic, depressed. Apex central, upper side covered with very fine tubercles. Ambulacra petaloid, open, lanceolate, subequal, extending about two-thirds from the apex toward the periphery, the posterior ones closer together than the others. Anus situated on the upper surface, in a deep depression, of a pyriform shape, narrow above and suddenly widening toward the periphery. Lower surface of test concave, covered with larger, more widely separated tubercles. Mouth subcentral, surrounded by a floscelle. Diameter ca. 110^{mm}, height ca. 28^{mm}.

The peculiar shape of the anal depression brings this species into the genus *Cyrtoma* of McClelland (Calcutta Journ. Nat. Hist., 1840), a synonym of which is *Stigmatopygus* of d'Orbigny. It is the first Tertiary representative of this so far exclusively Cretaceous genus.

Lake Pueyrredon.

VERMES.

4. *Serpula patagonica* sp. nov. Tubes solid, calcareous, cylindrical, irregularly contorted and vermiculate, growing

upon shells, stones, etc. Outer surface transversely rugose. Diameter, 3mm.

San Julian.

5. *Terebella magna* sp. nov. Large cylindrical tubes, isolated or growing in groups of two or three, straight or slightly curved. Walls composed of large and irregular fragments of shells. Inner surface of tubes smooth, outer surface very rough. Diameter of inner tube, 12–15mm.

Systematic position of these tubes, apparently built by a worm, doubtful.

San Julian.

BRYOZOA.

6. *Melicerita triforis* sp. nov. Zoarium foliaceous, lobate. Zooecia hexagonal, disposed quincuncially on both surfaces of the zoarium. Orifice crescentic, large, about in the middle of each cell. Besides there is an ovarian opening on the summit of the cell, and two (? avicularian) openings on the side of the mouth.

The three openings in the upper part of the cell distinguish this species from all the rest.

Upper Rio Chalia.

7. *Reticulipora patagonica* sp. nov. Closely resembling *R. transennata* Waters (Quart. Journ. Geol. Soc., vol. xl, 1884, p. 689), and differing only, if at all, in the branches of the zoarium being a little stronger, and the zooecial openings being more crowded.

Santa Cruz.

8. *Tennysonia subcylindrica* sp. nov. Closely resembling the only known species of the genus, *T. stellata* Busk (Cat. Mar. Pol. Brit. Mus., 3, 1875, p. 34), but differing by the more slender branches of the Zoarium, which are subcylindrical, and the slightly prominent orifices of the cells.

Santa Cruz.

PELECYPODA.

9. *Modiola andina* sp. nov. Shell small, elongated. Apex near anterior end. Both valves convex, with a blunt ridge running down from the apex to the posterior and inferior end. This ridge is slightly curved, concave toward the lower margin. Upper margin almost straight in its anterior part, forming a blunt angle with the straight posterior part, which passes in a regular curve into the posterior margin. Ventral margin concave. Surface of shell in the upper half (above the oblique ridge) finely radially striated. Lower part of surface smooth, only near the anterior end, below the apex, with a few fine striæ. Length of shell, 24mm; height, 9mm.

Lake Pueyrredon.

10. *Nucula reticularis* sp. nov. Shell small, moderately convex and moderately thick, subovate, oblique. Posterior and anterior dorsal margin slightly convex, ventral margin strongly arcuate. Surface with very fine concentric ribs, which are irregular and often bifurcate. These ribs are crossed by still finer radial striæ, which give a beautifully reticulated appearance to the shell. Ventral margin finely crenulated on inner side. Hinge teeth fine, both parts of the series forming an obtuse angle, anterior part with ca. 9, posterior with ca. 18 teeth. Length, 7·5^{mm}; height, 6^{mm}.

The sculpture of this species is of the type of that of the Oligocene *N. chasteli* Nyst.

Santa Cruz and Mt. of Observation.

11. *Crassatella quarta* sp. nov. Shell elongated-ovate, comparatively thin, not very convex. Apex only slightly prominent. Anterior end rounded, posterior hardly angulated and hardly narrowed. Posterior dorsal margin straight near apex, anterior almost straight, with only a slight suggestion of concavity close to the apex. Surface ornaments as in *C. Lyelli* Sowerby, but the ridges more crowded and a little less developed. Ventral margins without crenulations. Length, 17^{mm}; height, 10^{mm}, but growing larger.

Santa Cruz; Lake Pueyrredon.

12. *Glycimeris regularis* sp. nov. Shell elongate, convex, with concentric lines of growth and undulations. Apex at $\frac{1}{3}$ of the length, incurved. Anterior end rounded, posterior subtruncated, not narrower than anterior. Ventral margin straight in the middle. Long., 78; height, 45.

This form does not agree with any of the described Patagonian species, and accordingly I think it is new, although all the distinctive characters are taken only from the external form.

Santa Cruz; San Julian; Lake Pueyrredon.

13. *Corbula hatcheri* sp. nov. Shell small, solid and thick, subovate-triangular. Right valve very little larger than the left, both moderately convex. Anterior end rounded, posterior produced, subtruncated, an angular ridge running from apex to posterior angle. Ventral margin arcuate, posteriorly a little concave. Lower margin of right valve reflected toward the left valve. Surface with concentric ribs, which are rounded and rather crowded. Length, 11; height, 7·5; diameter (of right valve), 2·5^{mm}.

Santa Cruz; Las Salinas; Mt. of Observation; San Julian.

14. *Martesia pumila* sp. nov. This species resembles much *M. patagonica* Phil. but is much smaller, the callous plate of the anterior margin is very small, and the ribs of the anterior part of the shell form a very obtuse angle with the lines of

growth of the posterior part. The radiating furrow is narrower, and is more inclined posteriorly, so as to render the posterior part of the shell smaller in comparison with the anterior. Length, 9^{mm}; height, 4^{mm}.

This does not seem to be an immature stage of *M. patagonica*.

Santa Cruz.

GASTROPODA.

15. *Liotia scotti* sp. nov. Shell small, rounded, flat above, with a large, open umbilicus below. Spire with four rounded whorls, increasing rapidly, suture deep. Last whorl with six revolving, equidistant keels, the keel nearest to the umbilicus the smallest, and disappearing within the umbilicus; the upper whorls show only the two uppermost keels. The keels are crossed by very fine striæ, and a number (15) of strong radial ribs; at the points of intersection of these ribs and the keels, there is a small conical tubercle. Last whorl a little deflected toward the mouth, which is circular and thickened. Height, 4^{mm}; diameter, 8^{mm}.

This species resembles much the recent *L. acrilla* of Dall.

Santa Cruz.

16. *Calliostoma observationis* sp. nov. Shell low, conical, not umbilicated. Whorls flat, last whorl on the periphery bluntly angular. Above this angulation there are five distinct revolving ribs; near the mouth, between the second and third (counted from above), a sixth rib begins to appear. In the upper whorls the second and fourth ribs disappear, so that only three ribs remain, besides the peripheral angulation, which shows as a fourth rib immediately above the suture. All these ribs, when fully developed, are subequal, flattened, smooth, about as broad as the intervals between them. The base of the shell has 9–10 revolving ribs of the same character. The outermost of them is not separated from the peripheral angulation by a broader interval. Height, 10·5^{mm}; diameter, 12^{mm}.

Mt. of Observation.

17. *Calliostoma cossmanni* sp. nov. Shell conical, higher than broad, not umbilicated. Whorls flat, the last one angulated, with a keel on the periphery, which is wholly exposed on the upper whorls, being situated close to, but above the suture. Upper whorls with five revolving keels, the lowermost, formed by the peripheral keel just mentioned, is the strongest. It is smooth, with hardly any trace of granulations. The uppermost and the third keel are stronger than the second and the fourth; the first, second, and third are distinctly granulated, the fourth with finer granulations. Toward the apex of the shell, the second and fourth keels disappear, so that only three keels are present, the two upper

ones granulated, the lower one smooth. Base of shell hardly convex, with six revolving keels, which are subequal, smooth, and narrower than the intervals. Height, 8^{mm}; diameter, 6·5^{mm}.

Santa Cruz.

18. *Calliostoma garretti* sp. nov. Shell conical, as high as broad, not umbilicated. Eight whorls, which are very slightly convex, suture shallow. Last whorl very bluntly angulated at the periphery, without a distinct keel. Surface of whorls, above the periphery, covered with numerous fine, revolving threads: there are, on the third whorl, about 7 of them, increasing to about 17 on the last. The number of the threads increases by intercalation, the new keels being at first smooth, but soon they equal the others, and become, like the latter, finely, but distinctly granulated. These granulations, however, are developed only in the upper three quarters of the whorl, the lower four or five threads remain smooth. The threads continue over the periphery to the base of the shell, which is slightly convex; their number, on the base, is about 24, and they are smooth, resembling in all other respects those of the upper part of the whorls. Height and diameter 17^{mm}.

Santa Cruz.

19. *Calliostoma iheringi* sp. nov. Shell conical, broader than high, umbilicated. Six whorls, which are sharply angulated, one angulation being formed by a sharp revolving keel in the upper part of the whorls, a second one—exposed only on the last whorl—formed by a peripheral keel. Suture distinct. Upper part of whorls (above upper keel) oblique, flat, with 5–6 revolving threads, which are slightly granulated; lower part vertical, slightly concave on the last whorl, with 6–7 fine, smooth threads. Base of shell slightly convex, depressed toward the umbilicus, which is moderately large. About 18 revolving threads on the base, which are smooth, more crowded and finer toward the periphery, a little stronger near the umbilicus. Height, 9·5^{mm}; diameter, 12^{mm}.

Santa Cruz.

20. *Crucibulum dubium* spec. nov. Cast suborbicular, depressed-conical. Apex central. On one side is the impression of the internal cup-shaped lamina, which was attached to the inner wall of the shell. No further characteristics can be given, since only a single cast is represented in our collection.

Arroyo Gio.

21. *Sigapatella americana* sp. nov. Shell suborbicular or subelliptic, depressed. Apex distinctly excentric. Surface with irregular, concentric, slightly lamellate striæ, crossed by very fine radial rugosities. Internal diaphragma spiral, colu-

mella excentric, margin of diaphragma slightly concave and slightly reflexed at the columella. Height, 16^{mm}; diameter, 49^{mm}.

Santa Cruz; Punta Arenas.

22. *Dolium ovulum* sp. nov. Shell ovato-globular, spire short, conical, acute, last whorl large. Surface with fine and crowded revolving striæ, which are sub-equal, only in the lower part finer ones are intercalated. Mouth large, elongated-oval, canal very short, truncated, straight and comparatively narrow. Inner lip without callous tubercles or folds. Outer lip slightly thickened. Height, 34^{mm}; diameter, 25^{mm}.

Santa Cruz.

23. *Tritonium morgani* sp. nov. Shell subfusiform, elongated, with three varices. Whorls with fine, unequal, spiral striæ and large tubercles, the latter, on the last whorl, in three spiral rows, those of the upper row large, ca. seven between two varices; those of the middle row (5–6) small, and those of the lower row (3–4) very indistinct. Columella smooth, with a few indistinct crenulations in the lower part. Canal comparatively long. Outer lip distinctly crenulated, with an indistinct canaliform emargination in the upper part, opposite which is a fold on the inner lip. Height, 63^{mm}; diameter, 28^{mm}.

Santa Cruz.

24. *Buccinum annæ* sp. nov. Shell subfusiform, elongate-oval. Spire long. Whorls 7–8, angulated, the angulation with a series of tubercles, 12–14 of them on the last whorl, which are continued downward as irregular longitudinal ribs. Upper part of whorls slightly concave, appressed toward the suture. Exposed part of upper whorls, below angulation, subcylindrical. Last whorl large. Mouth ovate, elongated, upper end subcanaliculate, lower end truncated, and with a short reflexed canal, forming a varix on the columella. Outer lip thin, smooth within. Height, 66^{mm}; diameter, 30^{mm}. This species belongs into the subgenus *Cominella.*

Santa Cruz.

25. *Fusus archimedis* sp. nov. Shell fusiform, spire shorter than the last whorl, scalariform. Whorls very prominently angulated, suture very deep. Upper part of whorls, above angulation, flat, obliquely descending from the suture, lower part, below angulation, very slightly convex, obliquely receding downward to the suture. Angulation blunt, with a number (10–13) of blunt, often indistinct tubercles. Surface of shell with fine revolving ribs on the lower part of the whorls and upon the angulation, but these ribs are absent on the upper part, above the angulation. Whole surface with distinct lines of growth, which have a squamiform appearance, where they

cross the revolving ribs. Last whorl large. Mouth triangular, continued into a long and straight canal. Height, 50mm, but defective on upper end; diameter, 25mm.

San Julian.

26. *Fusus torosus* sp. nov. Shell subturbinate or subfusiform. Spire short, rather depressed. Whorls four, last one very large. Surface with numerous fine spiral ribs, which are rather crowded and somewhat unequal, crossed by very fine, squamiform lines of growth. Whorls strongly convex, swollen, with ca. seven strong, variciform longitudinal ribs, which begin at the suture and become thick and swollen in the middle of the last whorl, attenuating again toward the lower end of the shell. Mouth ovate, continued into a canal of moderate length, which is slightly curved. Height, 31; diameter, 20mm. This species resembles somewhat *F. pyruliformis* Sow., from Navidad, and I would not hesitate to identify it with this species. But Sowerby's figure seems to be poor, and the account given by Philippi and Moericke of *F. pyruliformis* shows clearly that it is different.

Santa Cruz.

27. *Fusus cancellatus* sp. nov. Shell small, fusiform, elongated. Spire a little shorter than the last whorl. Whorls convex, surface ornamented by revolving and longitudinal ribs, cancellated. Spiral ribs, in the upper whorls, 4–5, 12–18 on the last whorl; they are sharp, but flat, equidistant, narrower in the intervening spaces between the longitudinal ribs, and on the points of intersection with them slightly broadened, giving the appearance of low tubercles. Longitudinal ribs 12–13 on one whorl, rounded, but distinct, running from suture to suture, but disappearing on the canal. Mouth elliptical, canal comparatively short. Outer lip crenulated within. Height, 16mm; diameter, 6·5mm.

Santa Cruz.

28. *Fusus pilsbryi* sp. nov. Shell thick, elongated, fusiform; spire a little shorter than the last whorl. Whorls 7–8, convex, slightly appressed in the upper part, ornamented with 8–9 strong, rounded longitudinal ribs, which are slightly oblique and curved. On the upper whorls these ribs reach from suture to suture, on the last whorl they disappear below the middle. All of the surface of the shell is covered by very fine, numerous, distinct and subequal spiral striae. Mouth comparatively small, continued into a short canal. Outer lip thick. Height, 36·5mm (not quite complete); diameter, 12mm.

Santa Cruz.

29. *Murex hatcheri* sp. nov. Shell ovato-subfusiform. Whorls 5–6, rapidly increasing. Spire short, conical. Upper whorls angulated by a prominent, but blunt carina, which is

situated below the middle of the whorls; this carina forms an angulation on the last whorl, and below it there are 4–5 other carinae, decreasing in size. Upper part of whorls flat and obliquely descending from the suture, with a few revolving striae. Varices 5–6, lamelliform, strong and thick, at the points of crossing with the spinal carina produced into short leaf- or ear-like lobes, strongest on the uppermost carina. On the upper whorls only the uppermost row of lobes is visible. Mouth large, oval, with an open canal of medium length. Outer lip ornamented with 5–6 lobes, corresponding to those of the varices. Height, 63^{mm}; diameter, 44^{mm}.

San Julian.

30. *Urosalpinx elegans* sp. nov. Shell ovato-fusiform; whorls 5–6, convex, with spiral striae and 7–8 longitudinal, variciform costae, which are rounded. Mouth oval, elongated into an open, but narrow canal, which is about as long as the mouth. Outer lip distinctly crenulated within. Height, 16·5^{mm}; diameter, 8^{mm}.

Santa Cruz.

31. *Marginella oliviformis* sp. nov. Shell elongated, subcylindrically-fusiform. Spire conical. Surface of shell smooth and shining. Suture quite indistinct. Mouth long and narrow, canal very short, represented only by a rounded sinus. Columella with four subequal folds. Outer lip thickened, smooth within. Height, 11^{mm}; diameter, 5^{mm}; length of mouth, 6·5^{mm}.

Santa Cruz.

32. *Voluta petersoni* sp. nov. Shell elongated, fusiform. Surface beautifully cancellated by spiral and longitudinal ribs. Spiral ribs strongly developed, equidistant, sharp; longitudinal ribs a little stronger than the spiral ribs, sharp, running from suture to suture, ca. 30 on the last whorl. Cancellations rectangular, about twice as broad as high on the last whorl, and about three or four times as broad on the upper whorls. Spire slender, conical, mouth not much longer than half of the shell. Upper whorls quite high. Whorls almost evenly convex, only slightly appressed and concave near the suture. Mouth elongated. Columellar folds at least two, indistinct. Height, 148^{mm} (not complete); diameter, 65^{mm}.

Santa Cruz.

33. *Drillia santacruzensis* sp. nov. Shell turrite, subfusiform. Whorls 8, last whorl hardly half as long as the shell. Whorls convex, but depressed and slightly concave in the upper part near the suture. This depression forms a shallow furrow, following the suture, and is sharply separated from the rest of the whorl, which is ornamented by oblique longitudinal ribs, which end abruptly at the sutural depression. These ribs number 12–15 in one whorl. Besides, there are

very fine lines of growth, but no trace of spiral sculpture. Mouth elongated, canal short. Sinus of outer lip semicircular, situated in the sutural depression, close to the suture; at the point of junction of the outer lip with the columella there is a distinct nodulose, callous swelling. Height, 13^{mm}; diameter, 4·5^{mm}.

Santa Cruz

34. *Borsonia patagonica* sp. nov. Shell subfusiform, biconical; whorls ca. 6, last whorl a little larger than half of the shell. Whorls convex, depressed in the upper part, with a slight swelling just below the suture. Depressed part smooth, the rest ornamented by 10–12 longitudinal rib-like swellings, which are slightly tuberculiform on the upper whorls; on the last whorl they are rib-like, but less distinct. Besides the ribs, there are spiral cords on the lower part of the whorls; they are wanting on the depressed part, but continue, on the last whorl, upon the canal. Mouth elongated, canal of medium length. Outer lip with a moderately developed sinus, which is situated in the sutural depression. Columella with two plaits, the lower one sometimes quite indistinct. Height, 19^{mm} (not complete); diameter, 9^{mm}.

Santa Cruz.

35. *Actæon semilævis* sp. nov. Shell elongated-ovate, rather slender, spire short, conical, about one-quarter of the length of the shell. Whorls four, convex. Suture distinct, a slight carina running close to the suture and parallel to it. Below this carina there is an indistinct spiral groove. Below the latter the surface of the shell is smooth; but in the lower third of the last whorl there are 5–7 spiral furrows, which are rather broad, almost as broad as the flat intervals. Mouth elongated, wider below, columella with a distinct fold below. Height, 7^{mm}; diameter, 3·5^{mm}.

Mt. of Observation.

Crustacea.

36. *Scalpellum juliense* sp. nov. Only the carina known. Carina narrow, elongated, strong and solid, curved; basal margin bluntly pointed; surface smooth, only with lines of growth. Tectum strongly arched in its upper part, only slightly so in its lower; upper part solid, its cross section almost quadrangular, with a prominent ridge on the concave side, formed by the junction of the inflected parietes. Parietes very narrow, separated from the tectum by a distinct but blunt ridge. The carina of *S. solidulum* Steenstr. (See Darwin, Monogr. foss. Lepad., 1851, p. 42, pl. 1, f. 8) resembles so much the present fossil, that I have no doubt, we have to deal here with a closely allied species.

San Julian.

Species new for the Patagonian formation.

BRYOZOA.

1. *Cellaria fistulosa* (L.). (Hincks, Hist. Brit. mar. Polyzoa, 1880, p. 106.) This species is a living, almost cosmopolitan form, and has been found fossil from the Oligocene beds upward in Europe and New Zealand.

Shell Gap (Rio Chico).

2. *Aspidostoma giganteum* (Busk). (Busk, Rep. Challenger, vol. x, 1884, p. 161.) Known so far only living from southern Patagonia.

Santa Cruz and San Julian.

3. *Heteropora pellicutata* Waters (see Nicholson, Ann. Nat. Hist., ser. 5, v. vi, 1880). Known living from Japan and New Zealand, and fossil from New Zealand.

San Julian; Arroyo Gio.

BRACHIOPODA.

4. *Rhynchonella squamosa* Hutton (Cat. Tert. Moll. New Zealand, 1873). Fossil from New Zealand and Australia, living (*pixydata* Dav.) from Kerguelen Islands.

Lake Pueyrredon.

5. *Terebratella dorsata* (Gmel.). (Davidson, Trans Linn. Soc., 1887, p. 75.) Fossil in New Zealand, and living on the Patagonian coast.

Santa Cruz; Shell Gap; Lake Pueyrredon.

PELECYPODA.

6. *Mytilus magellanicus* Chem. (Reeve, Conch. Icon., vol. x, 1858.) Living on the Patagonian coast.

San Julian.

7. *Leda oxyrrhyncha* (Philippi), (Tert. und Quart. Verst. Chiles, 1887, p. 197). Navidad beds of Chile.

Santa Cruz and Arroyo Gio.

8. *Leda errazurizi* (Philippi), (Ibid. p. 196). Navidad beds of Chile.

Santa Cruz; Sierra Oveja (Rio Chico); Arroyo Gio; Lake Pueyrredon.

9. *Cardita elegantoides* Ortm. (Amer. Journ. Sci., 1899, p. 428), described from the Magellanian beds of Punta Arenas.

Santa Cruz and Mt. of Observation.

10. *Cardita volckmanni* Phil. (l. c., p. 173). Navidad beds of Chile.

Lake Pueyrredon.

11. *Venus chiloënsis* Phil. (l. c., p. 121). Chile.

Punta Arenas. (Known previously from this locality, but stratigraphical position not ascertained.)

GASTROPODA.

12. *Vermetus cf. intortus* (Lmck.). (Moerch, Proc. Zool. Soc. London, 1861.) Known from Oligocene to Pliocene deposits in Europe. The identification is not beyond doubt.
Shell Gap; Lake Pueyrredon.

13. *Galerus araucanus* (Phil.), (l. c., p. 92). Navidad beds of Chile.
Shell Gap; Lake Pueyrredon.

14. *Aporhais araucana* (Phil.), (l. c., p. 35). Navidad beds of Chile.
Santa Cruz.

15. *Buccinum obesum* (Phil.), (l. c., p. 48). Navidad beds of Chile.
Santa Cruz.

16. *Cancellaria cf. medinae* (Phil.), (l. c., p. 68). Navidad beds of Chile. Identification not quite certain.
Santa Cruz and Mt. of Observation.

CRUSTACEA.

17. *Verruca laevigatæ* Sow. (Darwin, Monogr. Balan., 1854, p. 520). Living on the coast of S. America.
Upper Rio Chalia.

Remarks on Synonymy, etc.

1. *Magellania lenticularis* (Desh.). What v. Ihering mentions as *M. globosa* I take for *M. lenticularis.*

2. *Ostrea ingens* Zitt. The large Patagonian oyster is absolutely identical with the New Zealandian species described by Zittel as *O. ingens*, and differs from *O. patagonica* of d'Orbigny. The latter is not found at all in the Patagonian formation. There is only one species in the Patagonian beds.

3. *Pecten proximus* v. Ihering. This species has been called by v. Ihering in his text (Rev. Mus. S. Paulo, 1897, p. 229) by the name of *P. centralis* Sow., but is different; I accept for it the name given by v. Ihering on the plate.

4. *Pecten geminatus* Sow. Synonyms of this species are: *P. quemadensis* v. Ih. and *P. fissicostalis* v. Ih.

5. *Cucullæa alta* Sow. I cannot distinguish v. Ihering's *C. dalli* from this species.

6. *Cucullæa darwini* (Phil.). There is not the slightest doubt, that *Cucullaria tridentata* of v. Ihering is this species.

7. *Pectunculus ibari* (Phil.). Synonyms of this species are: *P. magellanicus* Phil. and *P. pulvinatus cuevensis* v. Ih.

8. *Nucula patagonica* (Phil.). *N. tricesima* v. Ih. is only a variety of this species.

9. *Cardita inæqualis* Phil. This species is the most abundant form of the genus at Santa Cruz. Large specimens of it have been sent by v. Ihering to the Princeton Museum under the name of *C. patagonica* Sow., and thus it seems apparent that *C. patagonica* of v. Ihering is identical with *C. inæqualis* of Philippi.

10. *Cardita patagonica* Sow. We possess only the small variety, called by v. Ihering in 1899 (Neues Jahrb. Miner., etc.) *C. pseudopatagonica.* I believe that this is really the true *patagonica* of Sowerby.

11. *Venus navidadis* Phil. Already v. Ihering suggests that his *V. striatolamellata* may be identical with this species. I think that is right.

12. *Dentalium sulcosum* Sow. Synonyms of this species are: *D. majus* Sow., and *D. patagonicum* Rochebrune and Mabille.

13. *Gibbula dalli* v. Iher. *G. fracta* v. Ih. seems to be nothing else than the young of this species.

14. *Infundibulum clypeolum* (Reeve). Called by v. Ihering *Trochita magellanica* Gray. But the specific name of Reeve has the priority.

15. *Natica ovoidea* Phil. I take *N. famula* Phil. for the young stage of this species.

16. *Natica secunda* Rochebr. and Mab. The specific name *secunda* of Rochebrune and Mabille was published in 1885 (Bull. Soc. Philom. Paris, ser. 7, vol. ix) and has the priority over *N. obtecta* Philippi, 1887.

17. *Natica darwini* v. Ihering. According to v. Ihering the specific name of *N. solida* Sow. has been preoccupied by Blainville. He attributes the name *darwini* to Hutton, but I cannot find it in any of the publications of Hutton.

18. *Odontostomia suturalis* v. Ihering. *O. synarthrota* Cossmann (Journal de Conchyliology, 1899) is indistinguishable from this species.

19. *Turbonilla cuevensis* v. Iher. *T. iheringi* Cossmann (ibid.) is indistinguishable from this species.

20. *Struthiolaria chilensis* Phil. The extensive material at hand leaves it beyond doubt that *S. ameghinoi* v. Iher. is a synonym of this species.

21. *Fusus domeykoanus* Phil. *Siphonalia dilatata* var. *subrecta* of v. Ihering (1899) is this species.

22. *Trophon patagonicus* (Sow.). Abundant material of this species enables me to pronounce *T. laciniatus santacruzensis* v. Ihering as a form of this species, which is connected with it by numerous transitions.

23. *Urosalpinx cossmanni* nom. nov. For *U. cf. leucostomoides* Cossmann, non Sowerby.

24. *Voluta gracilior* v. Ihering. The specific name *gracilior* was introduced by v. Ihering in 1896 (Nachrichtsblatt Deutsch. Malakozool. Ges.) for *V. gracilis* Phil. (non Lea). It is impossible for me to distinguish from this species *V. quemadensis* v. Iher. The living *V. philippiana* Dall (1890) is different.

25. *Voluta domeykoana* Phil. *V. pilsbryi* v. Iher. (1899) does not seem to be different from this species.

26. *Pleurotoma subæqualis* Sow. What v. Ihering calls, in 1899, by the name of *Pl. discors* Sow. seems to belong to this species.

27. *Pleurotoma unifascialis* v. Ihering. This species has been regarded by v. Ihering (1897) as a variety of *P. discors*, but I think it is a good species.

28. *Geryon* (*?*) *peruvianus* (d'Orb.). *Cancer patagonicus* Philippi is apparently the same species as *Carcinus peruvianus* A. Milne Edwards (Ann. Sci. Nat., ser. 4, vol. xiv, 1860, p. 269). I do not think, however, that it is a *Carcinus*. It may belong to *Geryon*.

Princeton University, May, 1900.

Art. XXXVIII.—*The Cathode Stream and X-Light;* by William Rollins.

The Cathode Stream.

There are two opinions about cathode rays.

1. The rays are some phenomenon in the ether. Lenard considered them smaller transverse waves than those of light. Michelson thought they were ether vortices.

2. They are flights of material particles. Varley, who published his results in 1871, considered the cathode stream composed of molecules of the residual gas in the vacuum tube, charged with negative electricity. He deflected the stream by a magnet: showed the force of its impact on a pivoted mica vane. Crookes, who illustrated the earlier work of Varley and Hittorf by beautiful experiments, agreed with Varley as to the nature of the stream. He said the cathode stream particles left the cathode normal to its surface, moved in straight lines, coming to a focus in the center of its curvature. My experiments showed that neither theory of the cathode stream could explain all the facts. If it was possible to remove all the ether from an X-light tube, there would be no X-light, for no cathode stream could form, because a strain in the ether is essential.

The Ether Theory.—One characteristic of the Varley or cathode stream has not been explained by this theory: the stream can be deflected by a magnet, X-light arising where the deflected stream strikes. As there are also other objections, the pure ether theory will not be further considered. The experiments supposed to support it apply as well to the material particle theory.

The Material Particle Theory.—Since Varley's experiments the opinion has slowly grown that the particles in the cathode stream are not as large as molecules. The facts of physics and chemistry appear to prove that electricity breaks molecules into ions. Schuster therefore said the particles were the same Faraday ions as appear in electrolysis. Other physicists have further reduced the size, Weichert giving it as 1/3000 of a hydrogen atom, and the speed as one-third that of light. In regard to this speed, Rowland, in a remarkable paper before the American Physical Society in 1899, said there was no way of producing this velocity in a body though it fell from infinite distance on the largest aggregation of matter in the universe.

Weichert made the first determination of the relation between the charge and the mass of a cathode stream particle.

He gave this as 20×10^6 to 40×10^6 c.g.s. units. As this ratio is about three thousand times as large for a cathode stream particle as for a hydrogen ion in electrolysis, this physicist thought he must either assume a charge 3000 times as large, or a mass 1/3000 of a hydrogen ion. He chose the latter and other physicists have followed, though differing, some being willing to allow a cathode stream particle to be as large as 1/500 of a hydrogen ion. There is no proof of these suppositions. Weichert might have had the same ratio mean some other size for the particles.

Kaufmann found that this ratio was not affected by the gas or the terminals in a vacuum tube. I shall not quote authorities further, but group their statements to show what is called a sufficient explanation of the cathode stream by those who hold the material particle theory.

1. The cause of the cathode stream is a repulsion between the cathode and the charged particles of gas in the tube. This repulsion is due to the particles coming in contact with the cathode receiving charges of the same nature.

2. The particles are given off from the cathode perpendicularly to its surface, and move in straight lines, coming to a focus at the center of curvature of the cathode.

3. The direction of the particles in high vacua is independent of the position of the anode.

4. All the cathode stream particles move with equal speed, which is of the same order as that of light; they have the same charge; are of the same size.

5. In the cathode stream the charges are always carried by the same particles in all tubes, with any gas, with every cathode.

6. The cathode stream particles are the same in every atom in the universe. They are the ultimate particles of electricity.

7. In the cathode stream only one particle is detached from an atom. The remaining part has a positive charge.

8. The particles in the cathode stream are those liberated by ultra-violet light from a charged body; move with the same speed; have the same charge.

9. The particles in the cathode stream are those producing Becquerel light.

10. The particles in the cathode stream are the ultimate units from which the elements are formed. Each has a mass of 1/3000 of a hydrogen atom.

I shall now mention some of the experiments with X-light tubes which I have described in the Electrical Review during the last three years, grouping them under the headings given:

1. The cathode stream is a purely material particle phenomenon, with which the ether has no part. The sole cause of

the cathode stream is a repulsion between the particles of residual gas in the vacuum tube and the cathode. These two assertions are mentioned together, because one experiment applies to both.

An X-light tube was made with a biconcave aluminum cathode in the middle of its bulb. At each end of the tube was a platinum target. If the cathode stream was not affected by the ether, and depended entirely upon the repulsion between the cathode and the particles of residual gas, two cathode streams of equal intensity should have arisen from the cathode, producing the same amount of X-light at each target. All the X-light arising from either came from whichever target was made an anode. The experiment proved (1) that a space of strained ether was necessary, X-light arising with greatest intensity where the ether was most strained; (2) that the attraction of an anode was a cause of the cathode stream as well as a repulsion by a cathode.

2. The particles of the cathode stream are always given off from the cathode perpendicularly to its surface; move in straight lines, coming to a focus in the center of curvature of the cathode. Any one with experience can see the focus of the cathode stream when well developed in an X-light tube. By means of a pin-hole camera it may be photographed. Both methods prove that the distance varies not only with the degree of exhaustion in the tube, but also with the potential of the driving current.

I made a tube with a movable anode, whose distance from the cathode could be changed by a magnet. Under the conditions required for the economical production of X-light it was found necessary to have the target at twice the theoretical distance for it to be in the focus of the cathode stream. This experiment showed that the particles did not move in straight lines provided they left the cathode normal to its surface, nor did they come to a focus at the center of curvature. The explanation I offered was as follows: The particles of the cathode stream have the same kind of electricity, therefore they repel each other, coming to a focus beyond the place required by the accepted theory.

3. The direction of the particles in the cathode stream is independent of the position of the anode at high vacua. The experiment described in paragraph 1 appeared to disprove this, but another is also mentioned.

An X-light tube was made with connecting bulbs, one containing the usual cathode and anode. In the other, encircling the stem of the cathode already mentioned, as it passed through this second bulb, was a ring that could be made an anode. When the tube was connected in the usual way with

the generator, the cathode stream arose from the concave side of the cathode, came to a focus on the normal anode, giving good X-light. This anode was then disconnected from the current. The supplementary ring terminal was made the anode. Under these conditions no cathode stream arose from the usual side of the cathode, consequently no X-light was produced at the normal anode. X-light arose in the other bulb from the spreading streams of cathode particles given off from the back or convex side of the cathode.

4. The cathode stream particles are always of the same size, move with the same speed, and carry the same charge.

If these assumptions were true we should always get the same effect when the particles struck the target in an X-light tube. We do not. Every one long familiar with the construction of such tubes knows that the quality of the light varies with the resistance of the tube. In the determinations of the speed no sufficient account was taken of the retarding effect of the gases in circulation in the tube. Suppose we try to keep this constant, even then the effect produced by the impact of these particles on the target in an X-light tube varies from other causes. To show this I made a tube in which the ordinary cathode could be covered by mercury. With the usual cathode the tube gave good X light. With the mercury cathode there was not enough X-light to see the bones of the hand, but the whole tube was filled with a brilliant white light. I explained this by saying that the particles in the cathode stream were heavier when the cathode was mercury than when it was aluminum, and the stream was composed of some light gas. In consequence the particles did not strike the target at so high a velocity, and when stopped were therefore not heated to so high a degree; hence were not such efficient centers of radiation for the short ether movements we call X-light, most of the energy appearing as ordinary light instead. Some of the experiments on which I based this heat theory will be mentioned later. If the particles in the cathode stream were always of the same mass, all cathodes should lose equally in weight in the same time, with the same amount of current. They do not. I also found that when the gas had been considerably removed from the terminals, cathodes of heavy metals lost in weight more rapidly than those of light metals, like magnesium and aluminum.

5. In the cathode stream the charges are always carried by the same particles, in all tubes, with any gas, with every cathode.

An X-light tube was exhausted while using heat and heavy surges until it yielded no X-light. Had the particles been

removed? Surely such a wonderful result was never before accomplished so easily.

My explanation was simpler. We depend upon gas amalgamated with the terminals to make an efficient cathode stream in an X-light tube. When the cathode stream no longer forms we have removed too much of this gas. Consider here the experiment with the mercury cathode already mentioned.

6. The cathode stream particles are the same in every atom. They are the ultimate units of electricity. If true, how explain the experiment mentioned in paragraph 5? Why should X-light have stopped? The terminals of the tube were constantly connected with a generator supplying electricity. They were good conductors. They were kept charged to a high degree. Is it not simpler to accept the explanation given in paragraph 5?

Consider another experiment. An X-light tube was exhausted by heat and pumping until no gas appeared in the pump. A current was then sent through it, producing X-light. Much gas appeared in the pump. The bubbles continued so long as X-light was produced. When, by continuing the current and pumping to remove the gas thus driven out of the terminals, the X-light died out, the bubbles stopped. While there were bubbles there was a normal cathode stream and X-light. Were the bubbles composed of the ultimate particles of electricity? Is electricity a gas with a familiar spectrum, or were these bubbles simply a common gas coming out of the terminals, thus forming a cathode stream, as stated in paragraph 5?

7. In the cathode stream only one corpuscle can be detached from an atom, the remainder of the atom being positive.

According to this theory, when the tube arrived at the condition mentioned in paragraphs 5 and 6, that is, when the normal cathode stream no longer formed, the cathode should have been left with a positive charge. The charge was negative.

8. The particles in the cathode stream are those liberated by ultra-violet light from a charged body, move with the same velocity, have the same charges. If true, we should get X-light from a cathode stream formed by allowing ultra-violet light to fall upon a cathode in an X-light tube connected with a capacity. I have not yet produced sufficient X-light in this easy way to use in my profession.

9. The particles in the cathode stream are those producing Becquerel light, have the same charges, move with the same velocity.

If true we could produce X-light from a vacuum tube with a radio-active cathode, without an electric generator. It would

only be necessary to exhaust the tube to the usual X-light vacuum. The particles in the cathode stream from the radio-active cathode would then meet with no more obstruction on their way to the target to produce X-light, than would be encountered by those of a cathode stream formed in the ordinary way.

A distinguished American physicist has expressed the opinion that the radio-active substances would be so intensified as to act as substitutes for the complicated and troublesome apparatus now required for producing X-light for medical purposes. Having a high regard for his opinion I abandoned experiments with X-light to work with these substances.

Experiments showed that the light from them was different in character from X-light, suffering diffusion in the tissues like ordinary light to such an extent that the bones even of the hand were not visible. The experiments indicated a difference, perhaps in velocity, between the units in the cathode stream and those of the radio-active substances, because the character of the two resulting radiations toward human tissues was not the same when produced in the same vacuum. Experiments of this nature require time and money. I was, therefore, disappointed with the results, for my interest in the subjects mentioned in this paper was a desire to find the most efficient radiation, to aid in the relief of human suffering.

10. A cathode stream particle has a mass only 1/3000 of a hydrogen atom. The particles are the ultimate units of which all the elements are composed. That atoms are compound is probably true, though not yet proved by experiment. The theory explains phenomena better than that of the indivisible atom. That the particles in the cathode stream are the ultimate units is absurd.

I shall make a few suggestions in regard to each theory:

On the theory of indivisible atoms, how shall we explain differences in atomic weight, except by saying that such is the nature of atoms? This is not a satisfactory answer to an active mind.

On the theory of a compound atom it may be explained by saying that a light atom has fewer ultimate particles than a heavy one, for as each particle must have the same weight there would be more in a heavy atom than a light one, to account for differences in atomic weights.

That the particles in the cathode stream, however small, are not the ultimate particles of which the universe is composed, is shown by their having a familiar spectrum. If we could make ultimate units give a spectrum, it would be a new one. In this connection I mention a statement made in my notes already referred to:

In working with X-light tubes I appeared to get the spectrum of hydrogen in the cathode stream though other gases were in the tube. Therefore, before we reach the ultimate units of which the seventy-five or more elements are composed, we must seek more powerfully disruptive forces than those in the cathode stream. The so-called ultimate, indivisible corpuscles of this stream cannot be the final units because they have a familiar spectrum ; vibrating in too many ways at approximately the same temperature.

The experiments published by Trowbridge in this Journal for September are the most important contribution to celestial physics since Kirchhoff proved the law of exchanges and told the nature of the Fraunhofer lines. Trowbridge always obtained the spectrum of water vapor in the cathode stream when a condenser was used. Therefore the cathode stream particles are not necessarily elementary. If such minute particles are compound, it shows that when elements combine, it is not their atoms which unite to form new molecules; the combination is far more intimate, a union of the particles of which atoms are composed. Long before we reach the heart of nature the present ultimate corpuscles will look to us more complicated than a wilderness of solar systems.

The X-Rays.

1. Röntgen considers them longitudinal vibrations in the ether.

2. Jaumann believes they have also a transverse component.

3. Goldhammer stated they were short transverse vibrations differing from light only in size.

4. Stokes advanced a theory of irregular pulses in the ether, partly positive, partly negative.

5. J. J. Thomson has modified Stokes' theory. He believes when a cathode stream particle is stopped, its charge performs a single oscillation, giving rise to a pulse in the ether.

6. Michelson has suggested that X-rays may be ether vortices.

7. Several physicists believe they are flights of material particles.

This list of great names might easily be made longer. Yet what do we know of the true nature of X-light? Nothing.

I shall make a few suggestions and describe one or two experiments:

J. J. Thomson has accepted most of Weichert's views of the cathode rays, and Stokes' ideas of the X-rays. He believes when a corpuscle is stopped, there arises in the ether a pulse whose thickness is equal to the diameter of a corpuscle. These pulses are the X-rays. According to this theory the thickness of the radiant area on the target from which X-light arises

cannot be greater than the diameter of one of his corpuscles, having a mass 1/1000 of an atom of hydrogen. Estimate the thickness on this basis. As a preliminary it is necessary to know the diameter of a hydrogen atom. This requires a liberal use of the imagination, as proved by the different estimates. Kelvin said an atom, or a molecule (he did not attempt to distinguish them) was from 1/100000000 to 1/1000000 of a millimeter in diameter. Meyer considered them smaller than a sphere 1/1000000 of a millimeter in diameter, or as small as $0{\cdot}2\times10^{-7}$ centimeter. The physical chemists require us to believe that a molecule is not a solid. Its atoms are arranged with ether between them. The diameter of an atom, therefore, is not equal to half the diameter of any molecule with more than one atom, while in complex molecules its proportion is smaller. Atomic diameters are probably not greater than 1/3000000 of a millimeter. The corpuscle theory of the cathode stream gives the mass of a corpuscle as not more than 1/1000 of a hydrogen atom. The diameter of a corpuscle would not exceed 1/30000000 of a millimeter. This then would be the depth of the radiant area on the target from which X-light could arise.

Consider the following experiment: An X-light tube had its target placed at an angle of 90° with the axis of the cathode stream. As close as possible to the area struck by the cathode stream was a narrow passage in a block of platinum, with openings raised one millimeter above the surface of the target, the length of the passage parallel therewith. Under these circumstances, if X-light arose only from a radiant area on the target, whose depth was measured by 1/30000000 of a millimeter, direct rays could but to a small extent have illuminated the passage, for this was on the top of a cliff thirty million times as high as the depth of the radiant area at its base, in deep shadow, except the opening nearest the radiant area. If the usual theory had been true, no bright image should have been formed on the fluorescent screen, by light coming through the passage. The light was so bright Fomms' bands were photographed with a short exposure. The experiment also appeared to show that X-light was not composed of the reflected ether vortices of the cathode stream or of minute material particles. As these are supposed to move in straight lines, they would have had difficulty in going into the passage in the platinum block to brightly illuminate the screen. Again, how could material particles shot from a charged anode escape having a charge and being deflected by a magnet? Suppose they did escape without a charge. When they went through charged aluminum they ought to have received a charge and been deflected by a magnet. They were not deflected. Was not the theory of X-light advanced in my

notes a better one? This was the theory: When the particles of the cathode stream strike the target, they are heated sufficiently to cause them to be radiant centers, from which the short ether waves we call X-light arise. As time is required for heat to decline, the particles are sufficiently hot, when they have rebounded opposite the opening of the passage, to be radiant centers. The wave fronts, therefore, go directly through the passage, to the fluorescent screen, brightly illuminating it. I have used the word heat not to distinguish this from electromagnetic phenomena, but to express a more persistent state, in the radiant particles of the cathode stream, after they have struck the target, than that represented by the single pulse of the usual theory of X-light. I mention an experiment bearing on this heat theory. An X-light tube was made with a hollow target. The area struck by the cathode stream could be cooled to a low temperature. When so cooled there was less X-light. This tube under the title of the A-W-L tube was made commercially, proving capable of converting a large amount of electricity into X-light, because with any cathode stream it was impossible to melt the target. I also designed a simpler tube for general use. The target rotated on an axis. Fresh metal could be brought to receive the force of the cathode stream when a hole had been melted.

Before closing this paper I shall consider the structure of the atom as seen by the cathode stream and X-light. After Röntgen discovered that some of Lenard's rays would show the bones of the hand, S. P. Thompson found the heaviest metals made the best targets in X-light reflecting focus tubes. The reason usually given is that light metals like aluminum allow X-light to pass through them, this part of the light being lost. Why should aluminum be transparent to X-light if this is an electromagnetic phenomenon like ordinary light? Maxwell's theory requires conductors to be opaque. Aluminum is a good conductor and should be opaque to X-light. It is transparent. If X-light is an electromagnetic phenomenon, we must find some way of explaining the transparency of aluminum. Consider first the solid atom theory. As the nature of a substance depends on its atoms, conductors must have opaque atoms if these are solid. If X light is an electromagnetic phenomenon it cannot travel through such solid conducting atoms. If it passes through a metal with solid atoms it must pass in the ether between them. If one metal is more transparent than another, the more transparent must contain more ether. On the solid atom theory how can we get more ether in aluminum than in platinum? The solid atoms are of one size. There are about as many of them in aluminum as in platinum, for the ratios of the atomic weights are about the same as the ratios of the densities. There is not

enough difference to account for aluminum being forty times as transparent as platinum. As we do not find enough difference in the amount of interatomic ether to account for the difference in transparency, we must give up the solid atom theory, for it fails here as it does in attempting to explain the cathode stream. Both phenomena require a compound atom. But the cathode stream theory, that the particles into which the atoms are broken are the ultimate units, cannot be true, for they have a familiar spectrum. A theory of the atom must meet these difficulties. The following is suggested. The atom is made of sub-atoms. The sub-atoms are the cathode stream particles. There are as many kinds of sub-atoms as there are elements. We should expect the cathode stream particles, therefore, to have familiar spectra. The sub-atoms are compounds. They are made of the ultimate units of which the elements are composed. These ultimate units have the same size and weight. As the atoms have the same size and different weights, light atoms must contain fewer ultimate units than heavy ones. There would be more space filled with ether in a light than in a heavy atom. When an electromagnetic phenomenon passes through an atom of a conductor, it can only travel in the contained ether, for this is the only transparent part. The atom with the most ether would be most transparent. Aluminum having more ether and fewer opaque particles, would be more transparent than platinum. Apply this theory to the following experiment, intended to show that the transparency of aluminum is not the only reason why aluminum is less efficient for a target in an X-light tube than platinum. I made a tube with the usual platinum target, covered with a thin veneer of aluminum on the surface struck by the cathode stream. Had the transparency theory been the true explanation, such a target should have acted toward X-light about as a glass mirror, silvered on the back, would have to ordinary light. As the X-light passing through the aluminum struck the platinum, only a little more could have been lost than with a target entirely of platinum. I never made an efficient X-light tube in this way. The following explanation was given. When a cathode stream particle strikes an aluminum target it is not so abruptly stopped as by a heavier metal. The heat of impact is not so high, the energy conversion extending over a longer time. The particles must be less efficient sources of X-light, if this is due to a high temperature. But why should a heavy metal target stop a flying particle more abruptly than a lighter one? I made this answer. Aluminum on the compound atom theory given is a more open structure than platinum: on this account it would stop a flying particle less abruptly.

September 28th.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Ueber die physikalisch-chemishen Beziehungen zwischen Aragonit und Calcit.*—The object of this investigation by H. W. Foote was to show by purely physiochemical methods: 1. which of the two minerals under the existing conditions of temperature and pressure is the more stable; 2. whether the temperature of transformation is higher or lower than ordinary temperature. The method of investigation consisted in determining the relative solubility of the two minerals at different temperatures, as it is known on theoretical grounds that the least soluble must be the more stable. The best results were obtained by determining the electrical conductivity of aqueous solutions saturated with calcite or aragonite and carbon dioxide at atmospheric pressure and varying temperatures. It was found that calcite is more stable than aragonite at the temperatures experimented with, and that the solubility curves approach each other as the temperature rises. The author believes, however, from his own results and those of others, that at atmospheric pressure, calcite, below its melting point, can never become the less stable of the two minerals. From this it is concluded that the paramorphism of calcite after aragonite is theoretically possible, and the opposite paramorphism impossible. It is the author's opinion that rapidity of crystallization is one of the causes of the formation of aragonite.—*Zeitschr. physikal. Chem.*, xxxiii, 740. H. L. W.

2. *Atomic Weight of Radio-Active Barium.*—It is well known that M. and Mdme. Curie have discovered a substance "Radium" which is found with the barium of pitch-blende. By systematic fractional crystallization of the barium chloride obtained from the mineral, more concentrated products have been obtained. Finally by partial precipitation of solutions of the latter by means of alcohol or hydrochloric acid the concentration has been carried still further. The last product made in this way was examined spectroscopically by Demarçay and found to contain apparently only a trace of barium. This result indicates the isolation of radium chloride, but the quantity of the product was too small for use in an atomic weight determination. For the latter purpose Mdme. Curie was therefore obliged to use a less pure material, in which, from the aspect of its spectrum Demarçay thought that there was more radium than barium. Her results in two determinations gave the numbers 174·1 and 173·6 for the atomic weight of the metal in this chloride. Since the atomic weight of barium is 137·5, radium should have an atomic weight much higher than 174. The valency of radium is not discussed, but it is evident that if this is greater than that of barium the indicated atomic weight would be much larger.—*Comptes Rendus*, cxxxi, No. 6. H. L. W.

3. *Artificial Radio-Active Barium.*—A. Debierne, who, it will be remembered, is the discoverer of "Actinium," the radio-active substance that is found with the titanium of pitchblende, has apparently produced active barium chloride from the inact ve salt by induction due to contact with actinium in solution. The effect is made more intense by precipitating barium sulphate in a solution containing actinium. The latter is carried down by the barium sulphate, the sulphates are then changed to chlorides and the actinium is precipitated by ammonia in the form of hydrate.

If barium and actinium are in contact in solution for a short time, the induced activity in the barium is insignificant; but this activity increases with the time of contact, at least for ten days or so, and a product was thus obtained which had several hundred times as much activity as ordinary uranium. The author decides that the radio-active barium chloride prepared in this way is different from the radiferous barium extracted from pitchblende (Curie's radium). In both cases the activity persists in all chemical transformations to which the barium may be subjected. The rays emitted seem to be similar; they ionize gases, cause phosphorescence in barium platinocyanide, act on photographic plates, a portion of the rays is deviated in the magnetic field, and the anhydrous chloride is spontaneously luminous in each case. Moreover, the "artificial" radio-active barium chloride may be concentrated by fractional crystallization from water or hydrochloric acid solution, when the crystallized part increases in activity in the same way as with radium. However, "artificial" radio-active barium differs from the radiferous kind in showing no spectrum. Demarçay examined a specimen of it which was about a thousand times as active as ordinary uranium and was unable to detect the radium lines, while with a product only ten times more active than uranium, extracted from pitchblende, the radium spectrum was very clearly visible. The author has observed a second difference, in that the activity of the artificial product diminishes with time. In three weeks the activity of some of it diminished to one-third, while the activity of radiferous barium chloride and of salts containing actinium increases at first and then remains constant. The author believes that the induced activity which he has studied is not due to traces of actinium or radium, on account of the methods of separation used, and moreover it is difficult to understand how contamination by active substances should take place only when the solutions had been mixed for a long time.—*Comptes Rendus*, cxxxi, p. 333. H. L. W.

4. *The Relative Values of the Mitscherlich and Hydrofluoric Acid Methods for the determination of Ferrous Iron.*—It has been known for a long time that concordant results were not always obtained by the two methods mentioned above, in the analysis of rocks and minerals. In Mitscherlisch's method the substance is decomposed at a high temperature by means of a mixture of three parts of sulphuric acid and one part of water,

by weight, in a sealed tube from which air has been expelled. According to the other method the decomposition is accomplished by means of a mixture of hydrofluoric and dilute sulphuric acids in a platinum crucible kept full of steam, or protected from the air by being surrounded by carbon dioxide. In each case the ferrous iron is determined by titration with potassium permanganate solution. HILLEBRAND and STOKES have now explained why, in many cases, the Mitscherlich method gives higher results than the other. It is due to the presence in many rocks of small quantities of pyrite or pyrrhotite, minerals which are readily oxidized by ferric sulphate under the conditions used in the method under consideration. The authors find that not only is the metal of the sulphide oxidized, but the sulphur is converted into sulphuric acid as well. The effect of sulphur is therefore very great, amounting in the maximum to an error corresponding to $13\frac{1}{2}$ times its weight of ferrous oxide, and the method should not be used for rocks and minerals which contain even a trace of free sulphur or sulphides. The authors have also shown that pure pyrite causes very little error in the hydrofluoric acid method.—*Jour. Am. Chem. Soc.*, xxii, p. 625. H. L. W.

5. *Grundlinien der anorganischen Chemie*, von WILHELM OSTWALD, 12mo, pp. xx, 795. Leipsic, 1900 (Wilhelm Engelmann).—The appearance of each new work by Ostwald causes astonishment as to his prolificness, as well as enthusiasm on account of the excellence of his productions. Perhaps no book that he has written is as important from an educational standpoint as the elementary inorganic chemistry under consideration. The author himself considers it in a certain sense the keystone of a long and zealous activity in connection with the introduction and propagation of the new foundations of chemistry brought forward by van't Hoff and Arrhenius. Notwithstanding this aspect of the work, a careful examination shows that undue prominence has not been given to the new physical chemistry. Moreover, the treatment of the latter as well as other theoretical topics is admirably simple and philosophical. The descriptive arrangement, according to elements and their compounds, is used as the basis of the book, the general laws being introduced as opportunity and convenience permit. No attempt is made to arrange the elements according to the periodic system, in fact this system is only briefly dealt with at the very end of the book. The work contains comparatively few illustrations, and not many experiments are described in detail. A few inaccuracies are to be noticed in the descriptive matter, particularly in the paragraphs relating to metallurgy. It is to be hoped that these will be rectified in the next edition.

The author deplores the tendency that has often been shown in text-books of elementary chemistry to descend to a lower intellectual plane than is the case with works on physics and mathematics used by students at the same period of study, and he is convinced that this need not be the case now that the subject is

less purely descriptive than formerly. It seems certain that this book will be extensively used, particularly by teachers and by students who have had some preliminary training, and it is to be hoped that an English translation will soon appear. H. L. W.

6. *The Elements of Inorganic Chemistry for Use in Schools and Colleges;* by W. A. SHENSTONE, 12mo, pp. xii, 506. London, 1900 (Edward Arnold).—The aim of this book is to provide a graduated course which may be used at a period during which pupils pass from childhood to adolescence. It begins with a course of experimental work for quite young students and develops into a text-book for those who are older. A striking feature of the work is the large number of experiments devised to enable the student to verify quantitative laws and relations. These experiments are well chosen and very clearly explained, and they will doubtless furnish many useful suggestions to teachers of chemistry. The sections on carbon include much that is usually omitted from books on inorganic chemistry. The periodic system is made the basis of classification after the non-metallic elements have been separated from the metallic. Electrolytic dissociation and ionization are only briefly discussed. H. L. W.

7. *Die Kohlenoxydvergiftung*, von W. SACHS. 8vo, pp. x, 236, Braunschweig, 1900 (Friedrich Vieweg und Sohn).—This monograph on poisoning by carbon monoxide treats the subject very fully in its clinical, hygienic and medico-legal aspects. An elaborate index of the literature is included in the work.

H. L. W.

8. *The Hall Effect in Flames.*—The theory of the wandering of ions in metals gives renewed interest to the phenomenon discovered by Professor Hall and known by his name. E. MARX discusses analytically the point whether the different velocities of the positive and negative ions in a magnetic field can account for the Hall effect, and reaches a value for the rotation coefficient. He concludes that the only possible way of reaching quantitative results in regard to the Hall effect is in the direction of flame conduction in a magnetic field. Arrhenius believes that the conveyance of electricity in flames is accomplished through electrolytically dissociated ions. The velocity of the ions with a fall of potential of unity is 10^6 times greater than in the case of electrolytes and very different in the cases of the positive and negative ions. So that we are led to expect a Hall effect a million times greater than in the case of electrolytes. A full account of the author's apparatus and his experiments is given and he reaches the conclusion that the Hall effect in flame gases has the dimensions which would be expected on the hypothesis of of wandering electrical ions in a magnetic field. The author's experiments, however, do not decide the question whether the Hall effect in metals can be explained by pondero-motive effects on wandering ions.—*Ann. der Physik*, No.8, pp. 798–834, 1900.

J. T.

9. *Wireless Telegraphy.*—It is well known that an earth connection is used in sending messages by wireless telegraphy, both in the sending and receiving apparatus. J. VALLOT and J. and L. LECARME maintain that this earth connection can be dispensed with for long distance transmission, and certain questions in regard to the part the capacity of the earth plays are thus opened. Their receiving apparatus was placed in a balloon, which rose to a height of 800 meters and was about 6 kilometers from the sending station.—*Comptes Rendus*, CXXX, pp. 1305–1307, May 14, 1900. J. T.

10. *The Spectrum of Radium.*—According to the investigations of Demarçay (Compt. Rend., cxxix, p. 717, 1899) radium is a new element and he gives a table of its wave lengths. C. RUNGE has examined the spectrum and finds most of the lines which are given by Demarçay in chloride of barium. The spectrum was investigated in air and the preparation was also heated in vacuum tubes and the spectrum showed no new lines.—*Ann. der Physik*, No. 8, pp. 742–745, 1900. J. T.

11. *Magnetic effect of moving electrical charges.*—M. CREMIEU has conducted an important experiment on this subject. He has endeavored to measure the inductive effect when the convective current studied by Rowland is started or stopped. He could not observe any such inductive effect, and therefore concludes that there is no magnetic effect such as Rowland observed and that the effect observed by him was not due to a moving electric charge. In a criticism of Lamor's treatise on the relations between ether and matter (Cambridge University Press, 1900) Professor Fitzgerald remarks, that the questions raised by this experiment is one of the most fundamental ones in the connection between ether and matter. If M. Cremieu's experiments are substantiated, they will overthrow existing theories of electro-magnetism.—*Nature*, July 19, 1900. J. T.

12. *What electric pressure is dangerous?*—In order to obtain light on this much mooted question Professor H. F. WEBER of the Zurich Polytechnic has conducted a number of experiments and reaches the following conclusions:

A simultaneous touching of both the poles of an alternating current circuit is dangerous as soon as the pressure exceeds 100 volts; and since it is impossible to free oneself the case must be regarded as fatal whenever immediate help is not at hand. With steady currents he found that all pressures between 100 and 1000 volts must be regarded as equally dangerous, and consequently there is no reason for not using higher pressures between 500 and 1000 volts since they lead to more economical working of traction lines. There is little danger of the public coming in contact with such lines.—*Nature*, Aug. 23, 1900. J. T.

II. Geology and Mineralogy.

1. *Recent Publications of the U. S. Geological Survey.*—The following volumes have been recently issued by the U. S. Geological Survey, Parts II, III, IV, V, VII of the Twentieth Annual Report. (See also this Journal, ix, p. 447.)

Part II. *General Geology and Paleontology.* Pp. 1–953, plates I to CXCIII. This volume includes six papers, as follows: G. F. Becker, Brief memorandum on the Geology of the Philippine Islands, pp. 1–8; T. N. Dale, A study of Bird Mountain, Vermont, pp. 9–24, pl. I, II; G. H. Girty, The fauna of the Ouray formation, pp. 25–82, pl. III–VII; I. C. Russell, preliminary paper on the geology of the Cascade Mountains in northern Washington, pp. 83–210, pl. VIII–XX; L. F. Ward, Status of the Mesozoic floras of the United States, pp. 211–748, pl. XXI–CLXXIX; David White, Stratigraphic succession of the fossil floras of the Pottsville formation in the southern anthracite coal field, Pennsylvania, pp. 749–918, pl. CLXXX–CXCIII.

Of these papers that by Prof. Ward was noticed at length in the last number of this Journal (p. 320). The paper by Prof. Russell is largely devoted to the glacial and post-glacial geology of the northern and eastern parts of the State of Washington. It is shown that during these times the valleys were filled with gravel and sand to a depth in general of several hundred feet. Subsequently the streams excavated channels through these deposits and in many instances removed them entirely. The portions of the gravel deposits which remain form terraces along the streams, some of which are a mile or more broad and have a down-stream gradient. The terraces occur even in mountain gorges and along torrential streams and in such cases have a conspicuous down-stream slope—not due to a tilting of the land—which is less steep than the gradient of the present streams. No evidence is found of a modern depression of the land of such a nature as to admit of the flooding of the valleys by the waters of the ocean. The prevalence of glaciers at this time shows a much colder climate and a greater amount of precipitation than at present.

Part III. *Precious-metal Mining Districts.* Pp. 1–595, plates I–LXXVII. This volume will be noticed later. It contains three papers: J. S. Diller and F. H. Knowlton, On the Bohemia mining region of western Oregon; W. Lindgren, On the gold and silver veins of Silver City, De Lamar and other mining districts in Idaho; W. H. Weed and L. V. Pirsson, On the Geology of the Little Belt Mountains, Montana.

Part IV. *Hydrography.* Pp. 1–660, plates I–LXIII. This volume contains the report of progress on stream measurements for the calendar year 1898 by F. H. Newall, pp. 1–562; also an account of the hydrography of Nicaragua by A. P. Davis, pp. 563–638. The very rapid development of this new department

of the Survey and its promise of great economic usefulness for the future are alike noteworthy. In the present volume we find not only the results of drainage measurements for prominent rivers over the whole extent of the country, but also the survey of reservoir sites and the discussion of conditions governing underground waters as reached for example by artesian wells, both the latter subjects of peculiar interest in the West. The discharge data are given with much fullness for a large number of rivers from Maine to California, and the results are presented in graphical form for the successive months of the year. In addition to the statistical matter, plans are presented whereby the limited water supply of certain arid districts and Indian Reservations may be more economically distributed. The closing portion of the volume gives the results of the investigations on the hydrography of Nicaragua made by Mr. Davis in 1898; the work was carried on in connection with the Nicaragua Canal Commission.

Part V. *Forest Reserves;* by Henry Gannett. Pp. 1–478, plates I–CLIX, in part folded maps. The forest reserves of the United States numbered 37 on July 1, 1899, and are distributed over eleven States. The general condition of these reserves is given in this report, and there are also special papers on the following districts: Pikes Peak, Plum Creek and South Platte Reserves, by John G. Jack: White River Plateau and Battlement Mesa Reserves, by George B. Sudworth; Flathead Reserve, by H. B. Ayres; Bitterroot, San Gabriel, San Bernardino and San Jacinto Reserves, by John B. Leiberg.

Part VII. *Explorations in Alaska* 1898. Pp. 494, with maps 1-25 and plates I–XXXVIII. In this volume are grouped the reports of G. H. Eldridge, J. E. Spurr, W. C. Mendenhall, F. C. Schrader and A. H. Brooks, on reconnaissance surveys in Western and Central Alaska. Besides the sketches of theoretical and economic geology much information is given regarding products, climate and feasible routes. Maps and routes of previous explorers are discussed and the general geographic knowledge of the region is brought down to date. Taken in connection with the "Map of Alaska" (U. S. G. S. 1898) and Schrader and Brooks, "Preliminary Report on the Cape Nome Gold Region" (U. S. G. S. 1900), this volume stands as the reference book for recent reliable information regarding Alaskan matters.

2. *Department of Geology and Natural Resources of Indiana, 24th Annual Report*, 1899; by W. S. BLATCHLEY, State Geologist. Indianapolis, 1900. Pp. 1–1078, 89 plates.—This report contains more than the ordinary Geological Annual Report. Six of the papers are concerning the Geology of the State. The first, by the Director, refers to the Natural Resources, and three others contain the reports of the State Inspector of Mines, the State Supervisor of Natural Gas, and the State Supervisor of Oil Inspection, respectively. Mr. Foerste contributes a discussion on the Middle Silurian rocks of the Cincinnati anticlinal region, the particular interest of which lies in his interpretation of the

synonymy of the several beds. The paper by J. A. Price on the Waldron Shale and its horizon gives details which will be of value to the general student of Structural Geology. In this paper a large number of detailed sections are given, running from the Silurian through the Devonian. The remainder of the book is devoted to four exhaustive treatises on the Natural History products of the State. Prof. E. B. Williamson furnishes a monograph on the Dragonflies of Indiana. Dr. R. E. Call gives an exhaustive and fully illustrated catalogue of the Mollusca of Indiana in which diagnostic descriptions of species are inserted. A catalogue of the Flowering Plants and the Ferns and their allies indigenous to Indiana is furnished by Prof. Stanley Coulter. And Mr. Blatchley contributes a short paper entitled "Notes on the Batrachians and Reptiles of Vigo County, Indiana." The volume is published in the usual style of the Indiana Reports; the paper being thin and the printing rather poor for reports of so great scientific value. W.

3. *Geological Report on Monroe County, Michigan*, by W. H. SHERZER. *Geological Survey of Michigan*, ALFRED C. LANE, *State Geologist.* Vol. vii, Part I. Pp. 1–240, pl. i–xvii.—The nomenclature adopted in the stratigraphical part of this report is as follows:—*St. Clare Shale* is essentially the equivalent of the Genesee Shale of New York: the *Traverse Group* is the name for the equivalent of the Hamilton of New York; *Dundee Limestone* corresponds closely with the beds from the Oriskany Sandstone to the Onondaga limestone inclusive; the *Monroe beds* are correlated with the Salina, Rondout, and Manlius beds of New York State. W.

4. *The Elements of the Geology of Tennessee*, prepared for the use of Schools of Tennessee, by J. M. SAFFORD and J. B. KILLEBREW, pp. 1–264, figs. 1–46.—Prof. Safford and Dr. Killebrew, the Commissioner of Agriculture, Statistics and Mines, have compiled a useful book for the use of Primary and Common Schools of the State. A glance through the book reveals nothing new; it appears to follow closely Dana's Manual of Geology, from which many of the illustrations are derived, and Safford's Geology of Tennessee, but the matter is brought down to the understanding of students of the lower grades, for whom it will prove a useful guide. W.

5. *Geological Survey of Canada*, G. M. DAWSON, Director.—The following papers of the Eleventh Annual Report have been received:

Report of the Section of Chemistry and Mineralogy, Part R, Annual Report, vol. xi, by G. C. Hoffmann. No. 695, pp. 1–55.

Section of Mineral Statistics and Mines, Annual Report for 1898, Part S, Annual Report, vol. xi, by E. D. Ingall. No. 689, pp. 1–193.

Catalogue of Canadian Birds. Part I. Water Birds, Gallinaceous Birds, and Pigeons, by John Macoun. No. 692, pp. 1–218.

Preliminary Report of the Klondike Gold Fields, Yukon District, Canada, by R. G. McConnell. No. 687, pp. 1–44. W.

6. *Correlation between Tertiary Mammal Horizons of Europe and America*, by HENRY FAIRFIELD OSBORN. (Annals N. Y. Acad. Sci., vol. xiii, No. 1, pp. 1 to 72, July 21, 1900.)—In the two papers here published together Prof. Osborn sets forth his mature views upon the Zoögeography of Tertiary Mammals. In the introduction he makes an urgent plea for the establishment of uniform divisions of the Tertiary and for the international usage of common terms both as to life stages and life forms, and expresses confidence that approximate synchronisms can be established between the European and American Tertiary formations. For several years he has been attempting to correct these correlations and three trial sheets have been prepared and submitted to experts in Europe and this country for their criticism; as a result he publishes the following as a preliminary expression of the approximate correlations of formations:

I. STRATIGRAPHICAL CORRELATION: PRELIMINARY.

Lyell's System.			Approximate American Parallels.
Pleistocene	Upper	Post Glacial	
	Middle	Glacial and Interglacial	
	Lower	Preglacial	? Equus Beds
Pliocene	Upper	Sicilien	? Blanco
	Middle	Astien	
		Plaisancien	
	Lower	Messinien	Upper Loup Fork
Miocene	Upper	Tortonien	Loup Fork
	Middle	Helvetien	Lower Loup Fork
	Lower	Langhien	and Upper John Day
Oligocene	Upper	Aquitanien	Lower John Day (Diceratherium Layer)
	Lower	Stampien	White River
		Infra Tongrien	
Eocene	Upper	Ligurien	Bridger and Uinta
	Middle	Bartonien	Lower Bridger
		Lutetien	Wind River
	Lower	Suessonien	Wasatch
	Basal	Thanetien	Torrejon
		Montien	Puerco

All the levels above the Stampien are regarded by the author as imperfectly established.

In discussing the available evidences of parallelism, the following are cited as some of the more important tests: I. Common Genera; II. Similar Stages of Evolution; and he refers particularly, under this head, to the pattern of the molar teeth, the transformation of the pre-molar teeth, the complication of molar

teeth, and reduction of digits; III. Simultaneous introduction of new forms, or immigration from outside regions; IV. The Predominance of Certain Types; V. The Convergence and Divergence of the Palearctic and Nearctic Faunae. In discussing the geographical distribution of Tertiary forms the original assumption is made that the animals of various families and orders have either originated in, or migrated into their present habitat in past time, so that the geological record as to their order of appearance is of first importance. And in investigating the distribution of the present time he finds it necessary to have an absolutely reliable correlation time-scale for the fossil faunae, and the problem he then sets for investigation is to connect living distribution with distribution in past time and to propose a system which will be in harmony with both sets of facts. The author adopts Salter's classification of geographical areas, and the terms Arctogaea, Notogaea, Neogaea, and makes an interesting distinction between such large tracts of land as have, from their long separation, become the centers of adaptive radiation for orders of mammals, from those smaller regions which have been isolated from each other for shorter periods by climatic or physical barriers. The first group of divisions of the earth's surface are called *realms*, and these are the main centers of adaptive radiation for the orders of mammals. The smaller divisions he calls *regions* and they have served as the centers for the radiation of families of mammals. The author closes his paper with a discussion of the sources of migration of mammals to and from the three great realms of the earth as above described. W.

7. *On the Flow of Marble under Pressure.*—A series of experiments has been carried on by F. D. Adams and J. T. Nicolson with pure Carrara marble, having as their object the investigation of the conditions under which the flow of rocks may take place when subjected to differential pressure. Their experiments are to be extended later to other limestones, as also to granite and rocks of different types.

The method of experiment adopted was as follows: heavy wrought iron tubes were constructed of thin strips of Low Moor iron about one-fourth of an inch in thickness; these were so made that the fibres of the iron ran around the tube. Polished columns of the marble, about an inch or somewhat less in diameter, and an inch and a half in length, were inserted in the iron tubes, under such conditions as to give perfect contact, and to leave an an inch and a quarter of the tube free at each end. Pressures up to 13,000 atmospheres were then exerted upon them by means of an accurately fitting steel plug. The marble was submitted to pressure under four conditions: first, dry, at ordinary temperatures, and again at 300° C. and at 400° C.; also in the presence of moisture at 300° C. The rate at which the pressure was applied was also varied, the time of experiment extending in the different cases between the limits of ten minutes to sixty-four days.

When the experiment was completed, the tube was slit longitudinally along two lines opposite to each other and the marble within exposed. It was uniformly found to be so firm and compact that a steel wedge was needed to split it through the middle, the half column adhering firmly to the sides of the tube. The deformed marble, while firm and compact, differs in appearance from the original rock in possessing a dead white color, somewhat like chalk, the glistening cleavage surfaces of the calcite being no longer visible. The difference was well brought out in certain cases where a certain portion of the original marble remained unaltered by the pressure. This had the form of two blunt cones of obtuse angle whose bases were the original ends of the columns resting against the faces of the steel plugs, while the apices extended toward one another into the mass of the deformed marble.

Special experiments on certain samples showed that, making all due allowance for the difference in shape of the specimens tested, the marble after deformation, while in some cases still possessing considerable strength, was much weaker than the original rock. It also appeared that when the deformation was carried on slowly the resulting rock was stronger than when the deformation was rapid.

By the study under the microscope of thin sections of the deformed marble, passing vertically through the unaltered cone and the deformed portion of the rock, the nature of the change that had taken place, could be seen clearly. The deformed portion of the rock could be at once distinguished by its turbid appearance, differing in a marked manner from the clear transparent mosaic of the unaltered cone. This turbid appearance was most marked along a series of reticulating lines running through the sections, which when highly magnified were seen to consist of lines or bands of minute calcite granules. These were lines along which shearing had taken place. The calcite individuals along these lines had broken down, and the fragments so produced had moved over and past one another, and remained as a compact mass after the movement ceased. In this granulated material were enclosed great numbers of irregular fragments and shreds of calcite crystals, bent and twisted, which had been carried along in the moving mass of granulated calcite as the shearing progressed. This structure was therefore cataclastic, identical with that seen in the feldspars of many gneisses.

Between these lines of granulated material the marble showed movements of another sort. Most of the calcite individuals in these positions could be seen to have been squeezed against one another and in many cases a distinct flattening of the grains had resulted, with marked strain shadows, indicating that they had been bent or twisted. They showed, moreover, a finely fibrous structure in most cases, which, when highly magnified, was seen to be due to an extremely minute polysynthetic twinning. The chalky aspect of the deformed rock was in fact due chiefly to the

destruction by this repeated twinning of the continuity of the cleavage surfaces of the calcite individuals, thus making the reflecting surfaces smaller. By this twinning, the calcite individuals were enabled under the pressure to alter their shape somewhat, while the flattening of the grains was evidently due to movements along the gliding planes of the crystals. In these parts, therefore, the rock presented a continuous mosaic of somewhat flattened grains. From a study of the thin sections it seemed probable that very rapid deformation tends to increase the relative abundance of the granulated material, and in this way to make the rock weaker than when the deformation is slow.

When the deformation was carried out at 300° C., or better at 400° C., the cataclastic structure described above, was not developed, and the whole movement was found to be due to changes in the shape of the component calcite crystals by twinning and gliding.

In the experiments where moisture was present, the deformation of the marble taking place at 300°, no change in the character of the deformation was detected. In other words the presence of water appeared to exert no influence, the marble was deformed as when dry at 300° by twinning and gliding alone without cataclastic action.

In order to ascertain whether the structures exhibited by the deformed marble were those possessed by the limestones and marbles of contorted districts of the earth's crust, a series of forty-two specimens of limestones and marbles from such districts in various parts of the world were selected and carefully studied. Of these, sixteen were found to exhibit the structures seen in the artificially-deformed marble. In these cases the movements had been identical with those developed in the Carrara marble. In six other cases the structures bore certain analogies to those in the deformed rock but were of doubtful origin, while in the remaining twenty the structure was different.

It appears, therefore, that by submitting limestone or marble to differential pressures exceeding the elastic limit of the rock and under the conditions described in this paper, permanent deformation can be produced. This deformation, when carried out at ordinary temperatures, is due in part to a cataclastic structure and in part to twinning and gliding movements in the individual crystals comprising the rock. Both of these structures are seen in contorted limestones and marbles in nature.

At elevated temperatures only the changes of the second kind, i. e. by twinning and gliding, take place. This latter movement is identical with that produced in metals by squeezing or hammering, a movement which in metals, as a general rule, as in marble, is facilitated by increase of temperature. There is therefore a flow of marble just as there is a flow of metals, under suitable conditions of pressure. The movement is also identical with that seen in glacial ice, although in the latter case the movement may not be entirely of this character.

The further results promised by the authors, of experiments on rocks of different kinds, will be looked for with interest.—*Proc. Roy. Soc.*, read June, 21, 1900.

8. *Report of the Section of Chemistry and Mineralogy;* by G. Chr. Hoffmann, Geol. Survey of Canada. Part R, vol. xi, 1900. Among the various points of general interest in this report we note the following:

Celestite occurs in radiating columnar masses in the township of Bagot, Renfrew Co.; an analysis by Johnston showed the presence of 14 p. c. of barium sulphate. *Hübnerite* occurs in narrow seams and in irregular masses with coarsely laminated structure at Emerald, nine miles from Margaree Forks, Inverness Co., Nova Scotia. An analysis by Johnston showed it to be nearly pure manganese tungstate (0·47 FeO); sp. gravity = 6·975. *Hydromagnesite* occurs in considerable abundance on the Cariboo road, 93 miles north of Ashcroft, Lillooet district, British Columbia. Other extensive deposits have been found on the east side of Atlin Lake, Cassiar district. *Natron* has been identified in Goodenough Lake, 28 miles north of Clinton, Lillooet district, B. C. When examined, at the close of the dry season, it formed a deposit over nearly the entire bottom of the lake (20 acres) and with a thickness of about 8 inches. It was estimated that the deposit contained 20,000 tons. Natural soda also occurs in Last Chance Lake, 8 miles distant. *Polycrase* has been found in the township of Calvin, Nipissing district, Ontario. It forms crystalline masses, one of them weighing more than 700 grams; color pitch-black; luster resinous; sp. gravity 4·842. It is associated with xenotime, magnetite, etc. Only a qualitative analysis has been made thus far.

9. *Florencite, a new mineral.*—Florencite is a new hydrated phosphate of aluminum and the cerium earths recently described by Hussak and Prior. It was first found very sparingly in the cinnabar-bearing sands of Tripuhy, near Ouro Preto, Minas Geraes, Brazil, where it is associated with monazite, xenotime and the titano-antimonates, lewisite and derbylite. It also occurs more abundantly in diamond-bearing sand from Matta dos Creoulos, near Diamantina and with the well-known yellow topaz at Morro do Caixambú. It occurs in rhombohedral crystals with f $(02\bar{2}1)$ as the prominent form, also c (0001) and r $(10\bar{1}1)$ and m $(10\bar{1}0)$ both rare. The angle $ff' = 108°\ 26'$ is not far from that of hamlinite (108° 2′); the vertical axes are 1·1901 and 1·1353 respectively. Cleavage basal, fairly perfect; fracture splintery to subconchoidal; hardness about 5; specific gravity 3·586; luster greasy to resinous; color clear pale yellow.

The mean of two analyses by Prior gave:

P_2O_5	Al_2O_3	Ce_2O_3 (etc.)	Fe_2O_3	CaO	H_2O	SiO_2
25·61	32·28	28·00	0·76	1·31	10·87	0·48 = 99·31

For this the formula is deduced $3Al_2O_3.Ce_2O_3.2P_2O_5.6H_2O$, not far from that of hamlinite.—*Min. Mag.*, xii, 244, 1900.

10. *Elements of Mineralogy, Crystallography and Blowpipe Analysis from a practical Standpoint;* by ALFRED J. MOSES and CHARLES LATHROP PARSONS. New enlarged edition, pp. vii, 44. New York, 1900 (D. Van Nostrand Company).—This new edition of the Mineralogy by Professors Moses and Parsons appears in an enlarged and much improved form. The special features of the original work which made it particularly suitable for the use of the technical student, or the worker in the field,—as the classification of species and their clear and concise descriptions—have been retained, while the crystallographic portion has been rewritten and developed so as to conform to the modern method of treatment and classification. Other parts have also been revised and improved, so that the work as a whole may well commend itself to a wider range of students and readers than heretofore.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Latitude-variation, Earth-magnetism and Solar activity.*—The following conclusions are reached by J. HALM after a discussion of the above subject.

(1) The changes in the motion of the pole of rotation round the pole of figure are in an intimate connection with the variations of the earth-magnetic forces.

(2) Inasmuch as the latter phenomena are in a close relation with the state of solar activity, the motion of the pole is also indirectly dependent on the dynamical changes taking place at the sun's surface.

(3) The distance between the instantaneous and mean poles decreases with increasing intensity of earth-magnetic disturbance.

(4) The length of the period of latitude-variation increases with increasing intensity of earth-magnetic disturbance.

(5) In strict analogy with the phenomena of auroræ and of magnetic disturbance, the influence of the eleven-year period of sun-spots, as well as of the "great" period, is clearly exhibited in the phenomenon of latitude-variation; and the same deviations from the solar curve as are manifested by the auroræ are also evident in the motion of the pole.

(6) The half-yearly period of the earth-magnetic phenomena influences the motion of the pole of rotation in such a way that its path, instead of being circular, assumes the form of an ellipse, having the mean pole at its center.

(7) The half-yearly period also explains the conspicuous fact of a rotation of the axes of the ellipse in a direction opposite to that of the motion of the pole.—*Nature*, No. 1610.

2. *The location of the South Magnetic Pole.*—The October number of the Geographical Journal contains an interesting account by C. E. BORCHGREVINK on the "Southern Cross" Expedition to the Antarctic in 1898–1900. The party wintered at Cape Adare on South Victoria Land, in latitude 71° S. and car-

ried on extensive exploration along the coast line, the farthest southern point reached being about latitude 78° 45′ S. As the result of magnetic observations made by the Expedition, the present position of the southern magnetic pole is located at 73° 20′ S., and 146° E. At Cape Adare the dip was found to be −86° 34′ and the declination 56° 2′ E. Observations of the dip were taken at seven other geographical positions, the maximum dip, −88° 1½′, being taken at the foot of Mt. Melbourne; on the west side of Franklin Island a dip of −86° 52′ was found. As Sir James Ross, in 1841, observed a dip of −88° 24′ some twelve miles north of Franklin Island, there seems to have been a decrease in fifty-nine years of 1° 32′; it is concluded that there is very little doubt that the magnetic pole is very much farther north and west than in 1841.

3. *Ostwald's Klassiker der Exakten Wissenschaften* (Wilhelm Engelmann: Leipzig, 1900).—The following are recent additions to this valuable series:

Nr. 110. Die Gesetze des chemischen Gleichgewichtes für den verdünnten, gasförmigen oder gelösten Zustand, von J. H. Van't Hoff. Pp. 105.

Nr. 111. Abhandlung über eine besondere Klasse Algebraisch auflösbarer Gleichungen, von N. H. Abel (1829). Pp. 50.

Nr. 112. Abhandlung über bestimmte Integrale zwischen imaginären Grenzen, von Augustin-Louis Cauchy (1825). Pp. 80.

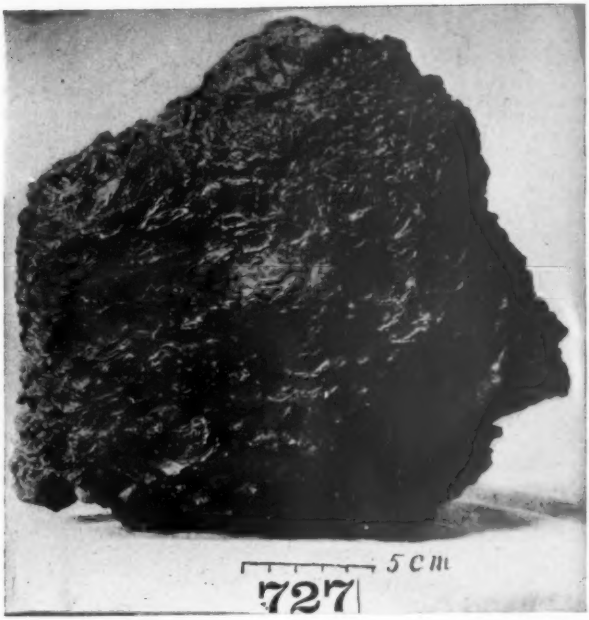
Nr. 113. Zwei Abhandlungen zur Theorie der partiellen Differentialgleichungen erster Ordnung, von Lagrange (1772) und Cauchy (1819). Pp. 54.

4. *Scientia.*—The inauguration of a series of small volumes on scientific subjects by G. Carré and C. Naud as publishers (Paris) was announced a year since (this Journal, July, 1899, p. 86). The seventh and eighth volumes of the physical-mathematical series have now been issued. The former is by H. Laurent and is entitled "*L'Élimination.* The author remarks that the only monograph on the theory of elimination is that of Fàa de Bruno published in 1859; hence the discussion given by him has peculiar value. The other volume is on the subject "*Tonométrie*" by F. M. Raoult.

5. *Introduction to Science;* by Alex. Hill, M.D. 140 pp. New York and London (The Macmillan Co.).—This little volume contains a series of interesting chapters on some of the scientific problems now before the public, as on the age of the earth, the origin of species, the constitution of matter, etc.

The Recent Solar Eclipse.—The report of the Expeditions organized by the British Astronomical Association to observe the total Solar Eclipse of May 28th, 1900, will be contained in a volume shortly to be issued from the Office of "Knowledge." The work will be edited by Mr. E. Walter Maunder, and will contain many fine photographs of the various stages of the Eclipse.

BLACK HILLS CYCADS.



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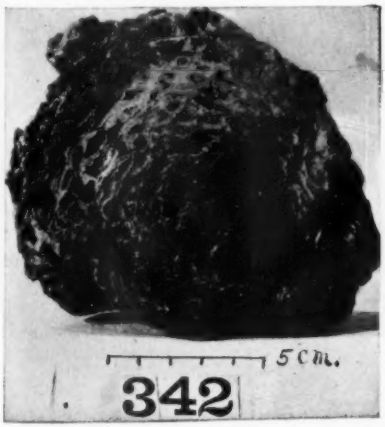
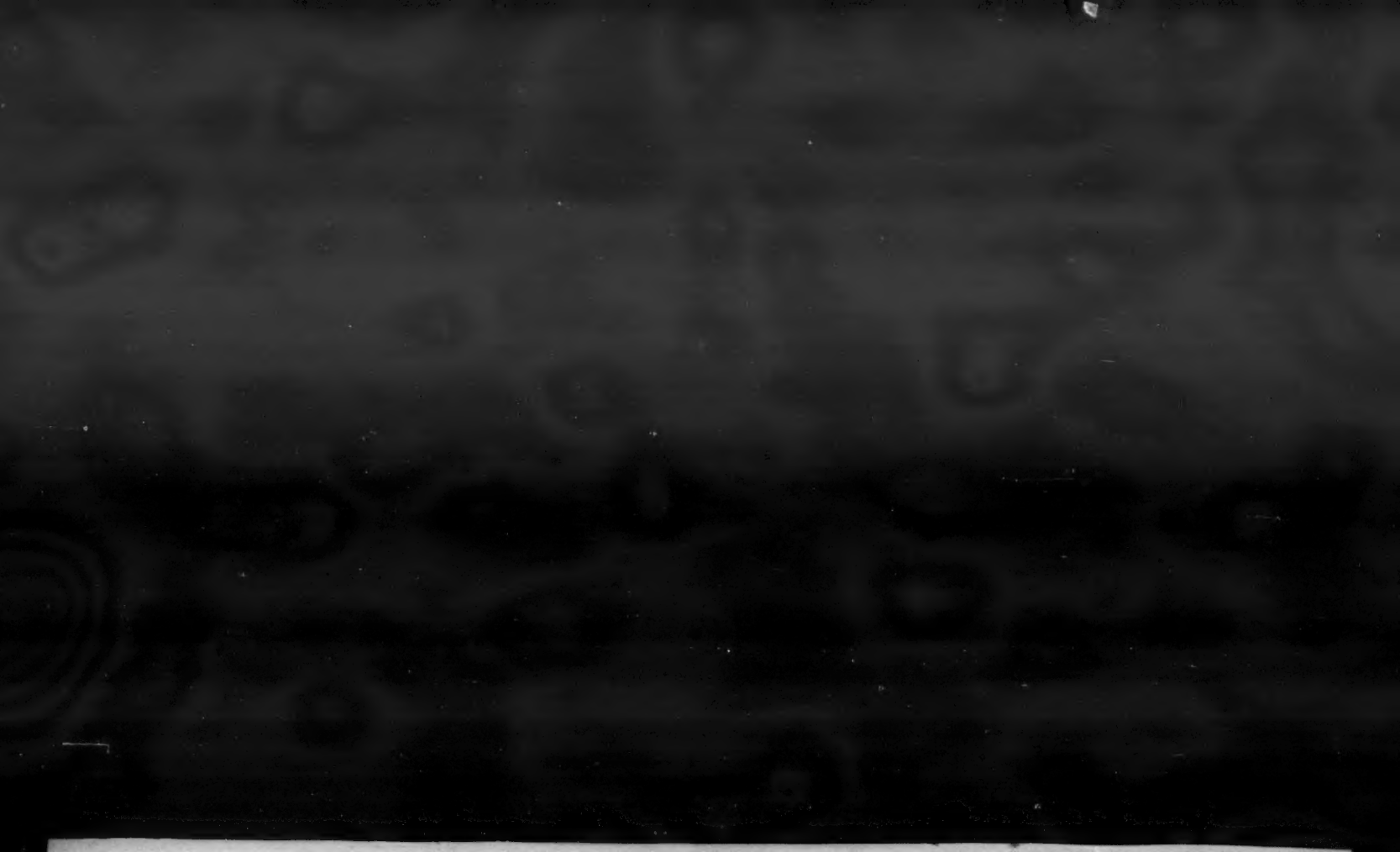
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